This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Tappan Presbyterian Association
LIBRARY.

Presented by **HON. D. BETHUNE DUFFIELD.**
From Library of Rev. Geo. Duffield, D.D.

Geo Duffield

Section
No

QE
261
.D366
E5
1810
v.2

GEOLOGICAL

TRAVELS.

VOL. II.

GEOLOGICAL

S : 873.

TRAVELS.

BY J. A. DE LUC, F.R.S.

IN THREE VOLUMES.

VOL. II.

TRAVELS IN ENGLAND.

TRANSLATED FROM THE FRENCH MANUSCRIPT.

London:
PRINTED FOR F. C. AND J. RIVINGTON, NO. 62,
ST. PAULS CHURCH YARD.

1811.

PRINTED BY LAW AND GILBERT, ST. JOHN'S SQUARE, LONDON.

Tappan Pres. Assocn.
9th
9-29-1924

TRAVELS

IN

ENGLAND.

452. I SHALL not attempt to relate all my observations in this country, where I have resided since the year 1773. Whenever I have had occasion to travel through any part of it, I have always been attentive to the geological phenomena which have presented themselves to my view; but as my object at first was only to examine whether any of the circumstances of those phenomena were either new to me, or contrary to the ideas which I had formed in other places, I seldom committed my observations to writing, or at most, I took but very short notes of them. It was the work of Mr. Playfair, as I have already had occasion to say, which made me sensible in how great a degree precise and numerous details were necessary for the determination of true general phenomena; and the observations of that gentleman having been confined to this island, I became desirous to study it with more attention, and especially to follow him in some of the places to which he had

referred. Whenever, in the course of the present travels, I shall arrive at any of these places, I will introduce his descriptions of them, and afterwards proceed to detail my own observations.

453. I shall have immediate occasion to enter on this plan. At the end of the preceding volume, I related the first part of my voyage from *Husum* to *England*; but I then said, that I should reserve for this volume its conclusion, from the time of my arrival in the packet, off the coast of *Suffolk*. This is the western coast of the *North Sea*; and with respect to the actions of existing causes, it will exhibit the same phenomena as the eastern and southern coasts. But the coast of *Suffolk* is more particularly interesting, on account of one of its phenomena, adduced by Mr. Playfair in support of that hypothesis of the Huttonian theory, which supposes, that, after the continents had been raised up, some parts of their coasts experienced alternate *subsidences* and *elevations*, at periods extremely modern in comparison with that of the birth of the continents themselves: an hypothesis tending to involve in uncertainty the geological *chronometer* which I had deduced from the known *progress* of the *new lands* along the coast. It is on this account that I have deferred till now the examination of that hypothesis; and when I shall have related the observations of other kinds which I made in sailing along the coast of *Suffolk*, I shall proceed to the above phenomenon, and to the consequences deduced from it by Mr. Playfair, giving

afterwards an account of what I myself observed respecting it.

Observations on the Coasts of SUFFOLK *and of* ESSEX.

Sept. 4*th* 1804. The captain of the packet in which I had embarked at *Husum* seeing the wind contrary to our reaching *Harwich*, made at first for *Yarmouth;* the wind changing afterwards, he resumed his former course; but as the ebb tide, the direction of which, on this coast, is from south to north, was then beginning, while the wind was not sufficiently strong to prevail against it, he cast anchor before *Lowestoffe.*

454. The weather was very fine, and we saw the whole coast distinctly: it is bordered with *cliffs* of different heights, many of which have ceased to crumble down, and are entirely covered with grass. The small town of *Lowestoffe* stands on the top of one of the cliffs in this state, the declivity being laid out in gardens. Here, as is the case wherever cliffs have been reduced into grassy slopes, the *strand* below them is wide and high; for this is indeed the circumstance to which they are indebted for not being any longer exposed to the attacks of the waves. On the strand under the hill of *Lowestoffe* there are many small houses, occupied by people employed in smoaking herrings.

455. The tide having turned at half past four the anchor was heaved; but the wind being unfavourable, we were obliged to make wide tacks, and consequently advanced very little. Every time that we returned towards the coast, I observed the strand to be very broad, as it generally is on coasts where the sea has little depth; which is the case here, there being even many sand banks; we found it necessary to make a very wide tack to avoid one of these, of great extent, and often shifting. At night, the tide again being contrary, and the wind not becoming more favourable, we cast anchor before *Orfordness.*

456. It thus appears that this coast, like all those which I have elsewhere observed, exhibits monuments of its own history; I shall point out others of different kinds, in the course of this voyage, in order to define them, and to shew clearly, from the beginning, what are the conclusions from them which the hypothesis of the Huttonian theory, hereafter to be examined, has a tendency to render uncertain. At the birth of the continents, occasioned by the retreat of the sea into its new bed, the fractures of the strata on the confines of that vast space must have produced, in various places, on the borders of the continents thus formed, abrupt sections, or *cliffs;* and wherever these were composed of soft strata, as they are on this coast, they soon began to crumble down. This then is one of the effects which have been *gradually* operated on the coasts, and which form *chronometers* by their *progress.* In parts where the sea

was originally deep, this degradation continued for a long time, and is in some spots still continuing; but in those where the sea was shallow, the materials on its bottom, being impelled by the waves against the coast, have formed a *strand*, on which are retained the materials falling from the cliffs. When the operation has arrived at this point, the attacks of the sea are nearly at an end: the larger fragments, as they fall, continue to raise and extend the strand; by this the waves are prevented from attacking the foot of the cliffs; and the rubbish still crumbling down from them forms a slope against them, which covers their front, and is at last bound by vegetation. The latter case has been seen at *Lowestoffe*; and repeated examples will occur, both of this state and of the former, in following the same coast.

Sept. 5th. We lay at anchor before *Orfordness* till seven in the morning, the wind till then continuing contrary; so that I had time to observe the coast, the strand of which was dissected into several promontories. The termination *Ness*, given to many places on these coasts, signifies a point of land advancing into the sea; thus *Orfordness* means *Orford point*. The coast is here gravelly, and this projection has been formed, like many others of the same kind, at the mouth of a river; its current, during floods, repels the gravel which the waves drive against the coast: here, and in many similar places, the gravel is accumulated on one side only; but this depends on circumstances, such accumulations being often formed on both sides of a river.

457. Pursuing our course, we passed before *Bawdsey Cliff*, which is high, and ot considerable breadth, and terminates a ridge of hills, stretching from some distance towards the coast. No parts of this cliff are as yet covered with grass, except its two extremities; the strand not being sufficiently raised in its front, because the sea is there very deep: before the part still crumbling down, no strand appeared; but it was probably covered by the high tide: I perceived one before the grassy parts.

458. At the southern extremity of this cliff, we passed before *Bawdsey Haven*, lying between the terminations of two ridges of hills: through the vale which separates these, and in which the tides ascend a considerable way, a small river arrives at the sea. Vales of this kind open to the sea on all coasts, being the channels by which the land-waters discharge themselves. These long and narrow spaces, ascended by the tides, are commonly called *creeks;* but they are also denominated *æstuaries*, from *æstus*, (tide); and as they will very frequently occur, I shall use the latter name, it being most appropriate to my purpose. The tides, as I was told, rise twelve miles up the æstuary of *Bawdsey;* and, as is the case every where, their sediments tend to fill it up. This, I say, is the case, without exception, in all similar

situations; and it being a monument of great importance in the *history* of the *continents*, I shall not fear to be thought tedious, if I point it out wherever it shall present itself: and here the æstuary of *Bawdsey* already can be ascended, up to a certain point, only by small barges following the tides. Thus *æstuaries* form a new class of *chronometers* on the coasts.

459. The end of the hill on the south of this haven resembles that on the north, being terminated by *Felixton Cliffs*, which, like the former, are grassy only at their extremities, where alone also a strand appears. But farther southward, all the cliffs are covered with grass, a very wide strand being there formed, some cultivated hills likewise descending towards it; and to the south of this, projects a large gravelly point of land, formed on the north of an æstuary at the entrance of which *Harwich* is situated. It is easy to perceive that all the abrupt hills terminating along the space occupied by this strand were originally cliffs, though now covered with vegetation. We arrived at *Harwich* at one o'clock.

460. I have often observed this part of the coast, which, by its nature, is exposed to great changes; as the cliffs on the south of the haven are the section of hills consisting of argillaceous intermixed with sandy strata. This is one of the circumstances most conducive to degradations, because the land-waters filtrate through the sand, and soften the clay. The position of this coast has contributed to prevent the

formation of a strand; because the current of the ebbing tides, which descend from the gulph of *Harwich*, having repelled to the north the gravel brought up on this side by the waves, no part of it arrives under these cliffs, and that which falls from their summit is in too small a quantity to form any sensible beach. Some other stony masses fall indeed from the same cliffs, and even in considerable abundance, yet without producing any permanent effect: these are argillaceous concretions, of the kind intersected by sparry veins, and called *Lusus Helmontii*; they are in themselves very hard, for they are used for paving; but the sea-water, when they are long exposed to it, dissolves and reduces them to clay; so that the waves of the high tides still beat against the foot of the cliffs, and these diluted materials, being carried along the coast, have already in great part filled up a neighbouring bay to the south.

461. In my former observations on this coast, of which I gave an account in the IVth Vol. of my *Lettres sur l' Histoire de la Terre & de l'Homme*, I had been assisted by the directions of Mr. PULHAM, one of the custom house officers. I called on him before I revisited the cliffs; and he told me that I should perceive great changes in them, as they had crumbled down very much since I had seen them last: this I found to be the case, when the tide became low enough to permit me to pass under them.

462. My principal object here before, had been a stratum containing marine shells, to which Mr. Playfair has referred in a passage that I shall presently quote; but he had not himself seen it. This stratum is met with in several parts of the neighbouring country at no great depth; and its section is seen at various heights in different parts of the cliffs. In my former travels, I had found it in some places to which I could have access; and I had taken out of it shells of several kinds. But the inclination of the strata occasions changes in the height of their section, after large portions of the cliff have given way; so that this last time I discovered this stratum at only one point, which I could not reach, on account of a rapid slope below it. Formerly, likewise, I had found on the strand abundance of these fossil shells, fallen from the cliff; whereas now there were very few; because so small a part of the stratum appeared.

Sept. 6th. The weather being dry, I went to observe the inner gulph, and followed at first the meadows bordering it on the southern and western parts, behind a promontory, on the extremity of which stands *Harwich*. These meadows are of the same nature as the *Marsches* described in the preceding volume on the opposite coasts of the *North Sea*, being likewise formed on the sediments of the tides and of the land-waters. This gulph is certainly original; for the waters cannot have produced any excavation, either behind a promontory, or where they have visibly raised the soil. I went on through these meadows, till I came to a little stream flowing towards the gulph; and there I was obliged to ascend the hill, and to make a great circuit, before I could reach the brow of a farther hill, whence I had a view of the whole extent of this large basin: as the tide was then out, its bottom was almost entirely dry; there being only a few channels kept open by the land-waters in the course of the streams of the ebbing tides. Of the former, the principal is the *Stour*, a small river which, having passed by *Maningtree*, enters the head of the gulph; but its vale, having been originally, for a considerable way, lower than the level of the sea, forms an æstuary of great extent.

463. It would be easy to convert into meadows the whole gulph, and the æstuary of the *Stour*; for this purpose, nothing more would be necessary than to close the entrance of the former, above the town, by an embankment with a sluice; but the port would then, in consequence, be soon filled up; for the miry sand, tending to accumulate in the channel, cannot be carried away but by the return of the tides from a wide space. Those parts alone, therefore, are enclosed with dikes, which are sufficiently elevated to be but seldom covered by the high tides; and these have been converted into meadows. From the spot where I stood, I could perceive that the hill on the opposite side, near the entrance of the gulph, had been at first a cliff of considerable extent; but

the part originally abrupt is now, in many places, overspread with grass, as it will soon be throughout. The other hills around the gulph, which at first were steep, are reduced into slopes covered with trees or bushes; and such as had originally more gentle declivities, are cultivated down to their foot.

464. I am acquainted with a great extent of this eastern coast of England, as well to the north as to the south of the part which I have just described, and the same phenomena are constantly repeated upon it, when the circumstances are the same: the original cliffs are reduced into grassy slopes, wherever the actions of the tides and of the waves have raised before them a strand of sufficient height; and on examining such as are not yet in that state, we may easily understand that in time they must be brought to it, by the formation of a similar strand. All the openings of vales, by which rivers originally arrived at the sea, and into which the tides extended, have been more or less filled up with the earthy particles deposited by the rivers; the tides detaining there those particles, and mixing with them the sand of the sea. All the new lands added to the continent, either in the front of low coasts, or within gulphs, are composed of the same materials; some of them, on this coast, are of great extent, as at *Deal* and *Ramsgate*; and all are absolutely horizontal, and continue to extend themselves, except where their extremity, being arrived beyond the reach of the sediments of rivers,

now receives no addition but of sea-sand, which the winds elevate in *dunes*, and scatter over the marshes.

465. These are new examples of phenomena, which I had already described in my *Lettres sur l'Histoire de la Terre & de l'Homme;* where I had shewn, from my own observations, that it was the same, not only on the northern coast of the continent, towards the *North Sea,* but on its western coast, towards the *Atlantic*, and on its southern, towards the *Mediterranean;* citing these facts in proof of two great points in the history of the earth; the one, that the sea has never changed its level, since our continents have existed; the other, that they have not existed during a very great number of ages.

466. It appears, from different circumstances, that, though Mr. Playfair is acquainted with the above work, he has given no attention to it; in particular, while he everywhere supposes our continents to be of an incalculable antiquity, he does not reply to any of the proofs which I have adduced to the contrary; he seems only, here and there, to make some allusion to those proofs, by the introduction of hypotheses intended to invalidate them. This appears with respect to the phenomena observed on the coasts; and it is in Note XXI, (P. 441.) that he endeavours, by one of these hypotheses, to involve in uncertainty the conclusions to which I have just referred.

"In speaking" he says "of the natural epochas
"marked out by the phenomena of the mineral
"kingdom, we have supposed a greater simplicity,
"and separation of effects from one another, than
"probably takes place in nature. We have, for
"instance, abstracted, in speaking of the waste and
"degradation of the land, from that *elevation* which
"may have been carried on at the same time. This
"appeared necessary to be done, in order to simplify
"as much as possible the view that was to be given
"of the whole; but there can be *no doubt*, that,
"while the land has been gradually *worn down* by
"the operations on its surface, it has been *raised*
"*up* by the expansive forces acting from below.
"There is even reason to think, that the *elevation*
"has not been *uniform*, but has been subject to a
"kind of *oscillation*, insomuch, that the continents
"have both *ascended* and *descended*, or have had
"their level alternately *raised* and *depressed*, inde-
"pendently of all action at the surface, and this
"within a period comparatively of no great extent."

467. According to this hypothesis, nothing could be proved, with respect to the *age* of the continents themselves, by the *chronometers* which I have pointed out on the coasts; as it would only be requisite to pretend that these coasts, having *subsided* after the birth of the continents, had been again *raised up*, but at a much *later* period; and such we shall find to have been the supposition of Mr. Playfair, with regard to a particular part of this eastern

coast. I think I have shewn sufficiently in my *Elementary Treatise*, that the theory of *elevations*, in itself untenable, when we consider that they could have been effected only by *expansible fluids*, is rendered still more so by a repetition of the *fractures* of the strata, which must have opened new passages for those *fluids*. But I set aside, for the present, this theoretical object, never examined by Mr. Playfair, in order to follow him in the facts adduced by him in proof of his theory of *alternations*; and one of the first which he cites, in P. 442, will bring us back to the coast of *Suffolk*. This is the passage.

" If we begin with examining the coasts of our " own island, we shall find clear evidence every " where, that the sea once reached higher up upon " the land than it does at present. The marks of " an ancient sea-beach are to be seen beyond the " present limits of the tide, and beds of sea-shells, " not mineralized, are found in the loose earth or " soil, sometimes as high as thirty feet above the " present level of the sea. Some of these on the " shores of the *Frith of Forth* are very well known, " and have been often mentioned. Indeed, on the " shores of that frith many monuments appear, " which would seem to carry the difference between " the present and the ancient level of the sea, to " more than forty feet." Farther examples of the same phenomenon are given in the two next pages; and in a note to P. 444, he introduces the following: " In the county of *Suffolk*, near *Wood Bridge*, at

" the distance of seven or eight miles from the sea, " are the *Crag-pits*, in which prodigious quantities " of sea shells are discovered, many of them perfect " and quite solid. (*Pennant's Arctic Zoology,* " *Introd. p.* 6.)" This is the most precise of the examples adduced by Mr. Playfair; I shall therefore confine myself to it, especially since it is one with which I am well acquainted,

468. Our continents having been formerly the bed of the sea, as has been acknowledged by all those who have paid any attention to the generality of terrestial phenomena, and in particular by Dr. HUTTON and Mr. Playfair, it is not surprizing that marine shells abound in the loose strata of their surface. The great preservation in which the shells are found, in many of these strata, having always embarrassed the geologists, who required, for some part of their systems, that our continents should be of incalculable antiquity, it appears to have been one of the objects in view in the formation of the Huttonian hypothesis of *subsidences* succeeded by *elevations*; and we have seen it thus employed by Mr. Playfair in the above passage. But the preservation of sea-shells in the loose superficial strata is not a phenomenon peculiar to the coasts; it is observed likewise in many of the interior parts of the continents; so that this hypothesis of alternate elevations and depressions would require to be extended to the continents themselves; which would render it still more improbable.

469. But let us consider this phenomenon, as it is observed on the coasts. If Mr. Playfair had given any attention to my work above mentioned, he would have seen, in Vol. II. Letter 40, that I had placed the phenomenon of the *Crags* of *Suffolk* among those concurring to demonstrate, by the nature of some of the *shells*, that the revolution, not very remote, in consequence of which the sea changed its bed, was accompanied by a change in the very nature of its liquid. This effect is manifested in particular by remarkable differences observed between the fossil shells found in these superficial strata near the coasts, and the shells now containing living animals in the neighbouring sea; of which we have here an example. The stratum called *Crags* in this county consists of sand, containing a great abundance of marine bodies; and as it is near the surface throughout a considerable extent of country, it is dug out, and used as a dressing for the lands. I have seen in various places the pits made for this purpose; they are on the same stratum of which the section appears in the cliffs: most of the shells contained in it are well preserved, and Mr. Playfair is right in concluding from this circumstance that a very long time cannot have elapsed since they came out of the sea; but is it by a partial elevation that they have been brought thence? Had this been the case, it could not have effected any change in the nature of the *liquid* composing the sea; and *shells* of the same kinds as those in the land would then be found upon the present coast. Now this stratum contains

in great abundance a species of *buccinum*, (found also in the cliffs of the coast of *Bretagne*,) which appears similar, at the first glance, to another, now living in the neighbouring sea; in both situations, these shells are found of various sizes, according to the respective ages of the individuals; but those in the stratum have this essential distinction, namely, that their revolutions are in the contrary direction from those of the living buccina. And not only is this fossil buccinum, so well preserved, no longer living in the neighbouring sea, but it is even not found in any other sea.

470. This is one of the numerous phenomena among marine fossils, respecting which I had entered into many details, because these phenomena, as well as the changes that have taken place among terrestrial *animals* and *vegetables*, are connected with the history of the sea itself, as proceeding from those changes of *chemical precipitations* in its bosom, which have produced the variety observable in our *mineral strata*. Every catastrophe undergone by these strata at the bottom of the sea was accompanied by the emission of new *expansible fluids* from the interior part of the globe; and while these changed the nature of the *precipitations*, and consequently that of the remaining *liquid*, they at the same time affected the *atmosphere* also. It was thus that such great successive changes were produced in the species of *organized bodies*, as well *terrestial*, as *marine*; changes, which are easily discovered on

comparing the fossil with the living species, and which continued to take place in both elements, till the last catastrophe, whereby, at the time when the sea changed its bed, all these operations were terminated. When this great revolution happened on the surface of the globe, the abundance of *expansible fluids* rushing out from its interior part produced a final and sensible change in the nature, as well of the liquid of the sea, as of the atmosphere, by which again a great number of organized bodies were affected, such as the *buccinum* of the county of *Suffolk*. I cannot repeat here all the facts which I have adduced to the same purpose, when I have formerly treated on this subject; but I shall give farther examples of them in *England* in the course of these travels.

471. After having cited this phenomenon on the coast of *Suffolk*, as a proof of relative changes between the level of some parts of the coasts, and that of the sea, Mr. Playfair proceeds to other phenomena, which he considers as concurring in this proof, but which he likewise relates without having become acquainted with them by his own observations. The cases first cited by him are in the *Baltic*, and have been already examined in the preceding volume of these travels; he next passes on to others, belonging to the *Adriatic*, and the shores of the sea near *Naples*, of which I spoke in my first work, where I shewed that they afforded no support to the idea of a relative change in the level of the continents

and of the sea. From these he proceeds to another example on the eastern coast of *England*, farther to the north than that which has been already our object; but it will be seen by the following passage, p. 452, that here again he argues from a phenomenon without having himself observed it; in which case, too much scope is allowed to the imagination.

" Appearances, which indicate such alternations
" as have just been mentioned in the level of the
" sea, are to be met with on some other coasts. In
" *England*, on the coast of *Lincolnshire*, the remains
" of a forest have been observed, which are now
" entirely covered by the sea. The sub-marine
" stratum which contains the remains of this forest,
" can be traced into the country to a great distance,
" and is found throughout all the *fens* of *Lincolnshire*. The stratum itself is about four feet thick;
" it is covered in some places by a bed of clay
" sixteen feet thick, and under it for twenty feet
" more is a bed of soft mud, like the scourings of a
" ditch, mixed with shells and silt. Here then we
" have a *stratum* which must have been once uppermost on the surface of the dry land, though one
" part of it is now immersed under the sea, and
" another covered with earth, to the depth of sixteen
" feet. A change of level in the sea itself will not
" explain these appearances: they can only be explained by supposing the whole tract of land to
" have *subsided*, which is the hypothesis adopted by
" the author of the description in the *Transactions*,

" M. CORRIA DE SERRA ; the *subsidence*, however, is
" not here understood to arise from the mere yield-
" ing of some of the strata immediately underneath,
" but is conceived to be a part of that geological
" system of alternate *depression* and *elevation* of the
" surface, which probably extends to the *whole*
" *mineral kingdom*. To reconcile all the different
" facts, I should be tempted to think, that the forest
" which once covered *Lincolnshire*, was immersed
" under the sea by the subsidence of the land to a
" great depth, and at a period considerably remote ;
" that when so immersed, it was covered over with
" the bed of clay which now lies on it, by deposi-
" tion from the sea, and the washing down of earth
" from the land ; that it has *emerged* from this *great*
" *depth* till a part of it has become dry land ; but
" that it is now *sinking* again, if the tradition of the
" country deserves any credit, that the part of it in
" the sea is deeper under water at present than it
" was a few years ago,"

472. I have not seen the *fens* (or *marshes*) of *Lincolnshire*, any more than Mr. Playfair ; but I have seen the same phenomenon on many other coasts : he ascribes it to an *elevation*, following a subsidence of the surface to a great depth ; and I am convinced, from what I have observed elsewhere, that, if he had been himself on the spot, he would there have perceived that all the circumstances, which he has described, may be explained by a continued *sliding*, down the slope towards the sea, of the *new*

lands produced by its sand and the sediments of the land-waters. In my first work, Vol. IV, Letter 85, and Vol. V, Letters 127 and 133, I gave circumstantial details, of similar cases, where the causes are evident; and in the course of these travels, I shall adduce new instances in many other parts of the coasts of *England*, and particularly in the *fens* of *Somersetshire*. It will then be seen that, with respect to the small *antiquity* of our *continents*, this *chronometer*, and many others observed on the coasts, cannot be silenced by hypotheses so unfounded, and so evidently the work of imagination, as that which I have just examined.

Travels in DORSETSHIRE.

473. As I have often travelled in this county, there are some parts of it which I have visited very frequently: to simplify my recitals, therefore, I shall sometimes give descriptions of places, without regard to any order of time, and sometimes also, in relating a particular journey, I shall introduce circumstances observed on a prior or subsequent occasion.

474. We are now coming to a coast on which the actions of the sea are exercised with the utmost force. I had formerly observed many of its parts, without taking notes sufficient for publication. But in the travels which form my present subject, though made at different times, my observations were regularly

continued and noted; these three questions being chiefly in my view—Whether the land-waters have cut their passage to the sea?—Whether the waters of the sea have opened for themselves an entrance into the lands?—And whether the earthy particles, carried to the sea by rivers, quit the coasts, and diffuse themselves over the depths of the ocean?—It will be seen, by the details into which my observations will lead me, that these three questions embrace almost the whole of the history of the earth; and indeed all the discussions, which have hitherto taken place in Geology, evidently shew the importance of not leaving these objects involved in any obscurity.

475. I think it proper to point out in this place, that it is impossible perfectly to understand the phenomena of the coasts, their different aspects, their intersections, projections, and recesses, unless observation be extended over the country near them. For whatever power may be assigned to the waters of the land and of the sea to change the state of coasts, phenomena are observed on the latter which are evidently connected with others in the neighbouring grounds; and in order to understand these phenomena, it is necessary to examine, in the interior part of the country, the state of the *strata* extending themselves towards the sea, and the connection between this state and that of the same *strata* in the *cliffs* on the coast. These *abrupt faces* which are supposed, in some systems, to have resulted from the attacks of the sea, present *sections* of the continental

strata: now we here see the strata, sometimes dipping in the sea, sometimes rising towards it: in other parts they are more or less inclined in the direction of the coast, and we consequently find their species changing as they arrive at the level of the water: lastly, after a succession of these cliffs, occur wide spaces, along which these strata are discontinued. Such are the phenomena requiring first of all to be explained; for untill the cause be discovered of this disorder in the *strata* on the borders of the continents, it can neither be decided why, in some places, the latter have abrupt coasts, while, in others, they descend with a gentle declivity, nor in what manner those channels have been produced, by which the land-waters pass across them in their way to the sea.

476. I shall begin the detail of my observations, by giving a circumstantial account of the country around *Weymouth*, that place having been the central point of my observations in this county. A phenomenon which I have described in several of the gulphs in the *Baltic*, namely, the *bars* formed at their entrance, is here repeated, with only the differences produced by tides; the latter uniting with the waves, not merely in repelling the sediments of rivers into the bays and gulphs, but in mingling with them the sand of the sea. Wherever the land-waters are conducted by a vale to any part of a gulph, their current, augmented by that of the retreating tides, clears away all accumulations from its course, which

it maintains along a certain line, the waves and the tides forming their deposits on its sides. Hence result these *bars* or slips of land, nearly closing the entrance of so many gulphs as I have described in the *Baltic*; among which those of *Sleswigh* and *Eckrenförde* most particularly resemble the gulph of *Weymouth*. A slip of land of considerable size, formed by the sea, here extends itself, from the foot of a hill on the north, almost across to the opposite hill, near which the stream of the *Wey*, and the course of the tides, have preserved for themselves a channel. On this slip of land is built the small town of *Melcomb Regis*, in the same manner as the lower part of the town of *Sleswigh* is placed on the corresponding slip; the town properly called *Weymouth*, like the other part of that of *Sleswigh*, standing on the opposite hill. At *Eckrenförde*, the whole town is on the slip of land; but there the port is more similar to that of *Weymouth*, as it lies between the extremity of the slip, and the opposite hill, and is crossed by a bridge. Besides this, at all the three places, the *bar*, or slip of land, formed by the sea, has enclosed within it a portion of the gulph; the part thus separated from the rest being at *Weymouth* called the *back-water*.

477. In the neighbourhood of *Weymouth* are many very important geological phenomena; but, generally speaking, there is scarcely any part of the coasts which may not become interesting to an attentive observer, if he makes it a central point of

observation, and examines the connexions of the inland parts with the aspect of the coast. I wish that the example, which I shall here give, of this method of proceeding, may produce researches of the same kind in various other countries, particularly wherever there is, near the coast, an island with which it may be compared. Thus at *Weymouth*, the *isle of Portland* becomes a great object of attention; since at the same time that its connexions with the neighbouring lands are such as to prove how erroneous is the opinion that islands so situated have been separated from the main land by the actions of the sea, they afford a remarkable example of the monuments remaining to us of the nature of the catastrophes, which happened at the epoch of the great *subsidence* of a part of the surface of the globe, whereby was produced the retreat of the sea into its present bed.

478. In this great assemblage of objects, there are some which I have observed very frequently; these therefore, as I have already said, I shall separately describe, without preserving the form of a journal. I shall begin thus with the *isle of Portland*, including in my description of it all the observations which I made at various times; having been directed and assisted in my excursions thither by Mr. PENN, Governor of the island, and Mr. BYAM, the clergyman of *Weymouth* parish, who had the kindness to accompany me. To the description of the island, I shall add that of the neighbouring lands.

Description of PORTLAND ISLAND *and of the* PROMONTORY *of* WEYMOUTH.

479. The way from *Weymouth* to *Portland island* is across an *æstuary*, the road to which lies either over a *promontory*, or along the strand at its foot. *Portland*, though still called an *island*, has long ceased to be really such. This great mass of rocks, about two miles distant from the coast at the nearest point, has been joined to it by an accumulation of gravel, called the *Chesil bank*, extending itself along the western coast to the length of fifteen miles, before it is united with the land. The interval between this *beach*, and the coast, which it follows at a small distance, is become an *æstuary*; because it is not only the channel wherein are collected all the land-waters, at first immediately reaching the sea in this space, but likewise that of the tides, which, when they ascend, carry into it sea-sand, and also retain there the sediments of the land-waters; thus tending to fill it up, at the same time that the waves elevate and widen the exterior shore of the bank, which reaches as far as the isle of *Portland*. It is therefore only within a small space that the æstuary can be crossed at a ferry, on the road from *Weymouth* to the island.

480. I must here define what it is that I call the *promontory of Weymouth*. It is the extremity of a ridge of hills, bordered on the S. W. by the æstuary

of which I have just spoken, and on the N. E. by the bay of *Weymouth* and the *back-water.* This distinct part of the ridge begins at its most elevated point, whereon is placed the church of *Wyke Regis,* and whence it descends insensibly, with various inflexions, towards *Abbotsbury* on the N. W.; but in the part which forms the promontory, it slopes down rapidly towards the sea.

481. Before I enter on the description of this latter part, I must explain the sense of the word *combe,* which I shall have occasion frequently to use in these travels; especially because, in this part of *England,* the names of many places, possessing the character implied by it, terminate with this word, which is probably Celtic, as it is used in the same sense in *Jura* and the *Alps.* This termination, indeed, occurs so frequently in the maps, that it may convey an idea of the general *form* of the country; and that form is, at the same time, an important geological feature, with regard to the question whether *running waters* have excavated their own *beds.* The *combes* are a kind of *vales,* which do not intersect the ridges of the hills, but terminate at some point in their upper part. Now some *combes* are as wide and deep, throughout a great extent, as the *vallies* in which *rivers* flow, and resemble those vallies with respect to their sides, though, at the same time, they contain only *rivulets.* The importance of this distinctive denomination will be shewn by very numerous examples;

amples; and I shall therefore henceforward adopt it.

482. All that part of the ridge of hills, which, descending from *Wyke Regis* towards the sea, constitutes the *promontory* of *Weymouth*, is divided by *Combes* in different directions; some are transversal, and, beginning from one of those intersections of the slope which form the various terraces that I shall presently describe, descend on opposite sides; others are longitudinal; the highest coming down to the terraces; and the lowest beginning from the latter, and descending to the shore, where they form small creeks. This shore begins from Cape *Lookout*, which is so called because it commands a view of the whole bay, and which forms on the *Weymouth* side, the extremity of this wide promontory. From this point, the shore, passing before the promontory, extends all the way to *Portland island*, being interrupted only by the æstuary above mentioned.

483. When this extremity of the hills is viewed from the sea, it is seen, in its descent from the highest point on which stands the church of *Wyke Regis*, to form, as it were, successive terraces, produced by the fractures of the strata, followed by subsidences more and more considerable down to the sea. The catastrophes of which these are the effects may be recognized by the following phenomena. In various parts are seen bare sections of the strata, rising above the slopes of their own fragments accumulated on

those portions of the same strata which have sunk to a lower level: at the foot of some of these slopes, there are marshy spaces, formed by the springs issuing from the intervals of the strata broken off above, their waters being retained by the plane of the strata which have subsided, and through which they cannot filtrate: lastly, the parts of the strata thus longitudinally fractured have experienced angular motions; and these have produced the *combes*, one side of which is generally formed by the sections of the strata, and the other by their planes.

484. The upper strata of these hills, such as they are found at *Wyke Regis*, over a certain extent of the summit, and also on some of the slopes, require to be observed with attention: they consist of *limestone*, and are distinguished from each other by the differences in the *marine bodies* contained in them; from which differences result proofs of *subsidences*, since the same strata that are observed on the hills are found, with all the symptoms of *fractures*, in several places at no great distance, at the level of the sea. Under these *stony strata*, there are several *soft* species; yellowish clay mixed with sand, commonly called *loam*, and used for bricks; pure bluish clay, of which pottery ware and tiles are made; and a bluish marl, scarcely distinguishable from the clay, but by the test of acids. These different *soft strata* shew themselves beneath the *stony*, wherever the sections common to all are not covered by the materials falling from them; but they are displaced and

in the greatest confusion in many parts of these hills, and particularly in the terraces, one below another, from *Wyke Regis* down to the shore. It would require too much time, were I to enter into details respecting these intermixtures of *strata*, which must originally have been deposited on each other in a certain order: I shall give examples of their recurrence in various places; but for the present, I shall confine myself to the description of the *strata* successively seen at the level of the shore, by following the extremity of the promontory, from *Cape Lookout*, in the way towards *Portland island*. This space will begin to exhibit evident marks of the catastrophes which overturned and displaced all these *strata*, at the epoch when the new bed of the sea was formed.

485. *Cape Lookout* is a separate mount; its *strata* slope downwards on the side opposite to the sea, where they leave a *combe*, into which a part of the town of *Weymouth* extends itself. This mount is abrupt on the side next the sea, and may be passed under at low water, because it is guarded by two moles, one of which is carried on far enough to break the waves, and to prevent them from attacking violently the foot of the cliff; and the other, flanking the hill on the *Weymouth* side and securing that part also against the waves, has allowed it to be reduced into a slope covered with grass.

486. The cliff of this cape shews, within a certain extent along the strand, an uncovered part of the abrupt section of its *strata*; the *upper* ones consist of a *marl-stone*, very easily distinguished; and under these are other *stony strata*, intermixed with *soft* ones. Now it may here be very plainly seen that this *cliff* has been produced by a *subsidence* of the *strata* on the side next the water; for the *bottom* of the sea is for a great way composed of the *uppermost* of these strata, and they form a shore at low water. It is very difficult to walk on this shore, because the surface, which is full of fractures, is covered with sea-weeds, and thus rendered very slippery. These *strata*, as far as they can be discovered under the water, are inclined towards the west; and having on that side slid down one on another, their sections form parallel lines, nearly at the same level. In walking westward, therefore, on the shore, the *strata* are seen to change, in consequence of this inclination. Their surface, being corroded, offers to view the marine bodies contained in them. In one of the first, I saw a great quantity of *chamæ*, with valves transversely channelled; the prominent lines being tuberculated. I afterwards observed another stratum, containing large striated *pectines*, and *pinnæ*.

487. Farther on, near a cape on which stands an ancient castle, the *strata*, continuing to form the shore and the bottom of the sea as far as it can be seen, are of a very different kind: their surface is so rugged, that, from a distance, they might be taken

for the scoriæ of forges, become rusty by exposure to the rain; but, when nearly surveyed, this corroded surface exhibits in relief a labyrinth of ramifications, interspersed with shells, among which are very flat large *ostreæ*, and large smooth *pectines*. These *stony strata* of so singular an appearance are the last that present themselves on the shore: those on the hill incline westward towards a *combe*, and are seen again only in a small space beyond it. The *strata*, both at the bottom of the sea and on the shore, are at first nearly horizontal; but beyond the fracture that has produced the *combe*, they also incline to the west, and are lost under the sand, which from thence to *Portland* island, forms a strand, and covers the bottom of the sea.

488. From *Cape Lookout* to this point, neither carriages nor horses can pass along the shore; so that the first part of the road from *Weymouth* to *Portland island* lies over the hills; but, as, at low water, a very good strand appears beyond the stony cliffs, there is a way to it down the *combe*, which, as I have said, intersects the strata of *limestone*. The strata of the mass remaining beyond this combe are inclined; and those of bluish *clay* begin to appear beneath, containing the same species of large flat *ostrea* as the stratum of *limestone* immedialy resting on them, but with the addition of large *gryphites*, of which none are found in the latter.

489. At this point, the *stony strata* cease; the cliffs beyond contain strata only of *clay* or *marl*, and the upper part of the hills consists of sand, mixed with siliceous gravel. These cliffs are still crumbling down, because, at high water, the waves reach their foot; hence they are in great part covered by their own fallen materials; but wherever the *strata* shew their section, they are seen to be still inclined towards the west; so that, in following the strand, these *soft strata* change at its level, in the same manner as the *stony* which precede them. But the assistance of some acid is necessary to distinguish these *soft strata* from each other, on account of the similar appearance of the *marl* and of the *clay*.

490. These differences in the nature of the *strata*, indicative of changes in the state of the sea, while those strata were successively formed within it, and deposited on each other in a horizontal situation, are accompanied in the *soft*, as well as in the *stony strata*, with differences in the *marine bodies* which they contain. In some strata, besides the large flat *ostreæ*, there are found prodigious quantities of small *gryphites* of a particular species; while in those immediately following, no marine body is perceived. Among the *argillaceous* strata is a species well known in this country; it shews itself in the cliffs of the coast, and, in consequence of the convulsions of the strata, it is found also in the interior parts of the land at different levels. The distinctive character of this species is, that it contains those argillaceous con-

cretions which are divided within by sparry partitions, and are called *Septa*, or *Ludus Helmontii*. The concretions of this kind that are found in these cliffs form flattened spheroids of different sizes, some of them very large. Now here, as well as in all other places where I have found these concretions, the cause of the *consolidation* (which Dr. Hutton thinks can be ascribed only to *heat*) directly shews itself; inasmuch as the *stratum* containing these masses makes no effervescence with aqua fortis, while much is produced by the concretions; and thus their *consolidation* appears to have been effected by the same calcareous substance, which has filled up the fractures occasioned by the shrinking of the clay.

491. On approaching the end of the promontory next to the *æstuary* which must be crossed to go to *Portland* island, the cliff becomes lower and lower; and when its strata of *clay* and *marl* have at last passed under the strand, nothing more is seen in it than the superficial soil of all these hills, consisting, as I have said, of sand mixed with siliceous gravel; and this soil, descending along the side of the promontory, borders the commencement of the æstuary. The strand is here very wide; and being formed of pure sea-sand, the winds have raised *dunes* on it against the foot of this part of the hills.

492. The position of the isle of *Portland*, as it appears in the maps of this county, corresponds, with the foregoing description of the *strata* in the *pro-*

montory opposite to it. From the highest part of the latter at *Wyke Regis*, the several masses into which the strata were broken, at the same time that they underwent lateral angular movements, subsided more and more towards the interval between the *island* and the coast: wherever the bottom of the sea, in this interval, is not covered with sand, it is seen to consist of the *stony strata*, which are the highest at the extremity of the promontory; and beyond, at the distance of two miles, rises the *island*, presenting also towards the intermediate space terraces one below another, composed as will appear, of the same kinds of *strata*. When all these correspondences shall have been attentively observed, the conclusion will naturally follow, that, in the series of *subsidences* more and more considerable, which, on both sides, have formed these successive terraces, a great intermediary subsidence has taken place, whereby all the strata have sunk below the level of the present sea: and this conclusion will be confirmed by the details into which I shall enter with respect to the *island*.

493. On arriving at the *æstuary*, it is impossible not to be struck with the appearance of the *Chesil bank*, that wonderful *beach*, which beginning from the *island*, extends itself along the coast to the westward for fifteen miles, before it is united with the latter. From its aspect, it might be taken for the great dike in *Holland* along the *Meuse*, which it resembles in its height, in its extended base, and in the

breadth of its top. Now when we consider that in this phenomenon art has had no share, we cannot but wish to discover the causes of its production; this I have endeavoured to do and I shall relate the result of my observations.

494. It is only at the entrance of the channel between the *Chesil bank* and the land, that it has sufficient depth to allow the passage of a ferry-boat large enough to transport carriages: this moves between two stretched ropes; to which effect there are on both sides rollers on its edge, resting alternately, against one of the ropes when the tide rises, and against the other when it descends. The small breadth of this entrance of the channel, between a bend of the *Chesil bank* and the coast, is the cause of its being deeper than other parts; because, as the current of the retreating tides is here confined, it drives out the sand before it; but below the ferry, the current, dispersing itself has no longer the same power; so that five or six hundred yards lower, towards the sea, the barges intended to ascend the æstuary cannot pass but at high water; the waves raising the sand and the gravel in that part as they do all along the strand extending to the island; and when the tide is low, horses and carriages can there pass across. At that time, the foot-way towards the island is very pleasant, the lower part of the strand consisting of pure sand; but the upper part, on which it is necessary to walk at high water, is, on the contrary, extremely fatiguing, all the gravel being

driven up thither by the waves: this is the foot of the *Chesil bank*; and its gravel, being rounded and without any mixture of sand, is quite loose and moveable under the feet. This prodigious accumulation of gravel proceeds almost entirely from *West Bay*; the bottom of the sea to the eastward consisting of pure sand, and being very shallow, while on the west it is very deep; so that here the waves, impelling the gravel from the bottom, are continually throwing it up, and during great tempests, they even cast it over the bank, high as it is at present. Near the island fragments of lime-stone, proceeding from it, are, on the eastern side, mixed with the gravel.

495. One of the remarkable circumstances of this *island*, whereby I shall be led to various conclusions, is the difference of its appearance on the two sides of the slip of land, which leads to it, and is bordered on the west by the *Chesil bank*. On the western side, where the sea is deep, the side of the island is cut down abruptly, almost to the level of the water; to the *Chesil bank* and the strand above mentioned, it descends in a grassy slope; and it is here that the village of *Chesil* is situated: on the east of this, where the sea is shallow, the side of the island forms a more rapid slope, and the greatest disorder prevails among the shattered masses, which have fallen one over another, and form, as it were, successive terraces.

496. When the slope descending to the slip of land is viewed from the western edge of the *Chesil bank*,

near the point of its junction with the island, it is seen to be cut down abruptly, as the *island* itself is on that side; its section discovering only a confused heap of rubbish; and at its foot there is a chaos of masses, descending rapidly towards the sea. These disordered masses extend along the foot of all this steep side of the island, the latter consisting, for the most part, of the section of different strata of *limestone*, below which, in some places, *soft marl* appears. The sea, as I have said, is here very deep; and the slope of the *Chesil bank*, higher in this part, continuing to descend under the water, it cannot be seen on what it rests; but there is every appearance, as I shall shew, that it is on a part of the same strata that compose the *island*, which when the rest sunk down to the bottom of the sea, remaining at a higher level, formed a *sub-marine* bar, inclining towards the east, and abruptly cut on the west by a greater subsidence on that side; and of this I shall in the sequel determine some other essential characters.

497. The whole *island*, in its surface as well as on its borders, bears marks of the great catastrophes which happened at the period when the sea changed its bed. The highest part of the island is on the north side, where the signal-post stands; and from this point, the *strata* are seen descending, not regularly, but as it were in masses, to the opposite point, where are the light houses. The highest part forms a down, and affords pasture for sheep; the *Portland* mutton being reckoned particularly fine: all the rest

of the island is in tillage; and nothing can present a more barren and dreary appearance than that part of the soil after the harvest is over; for it consists everywhere of lime-stone rubbish, without either trees, bushes, or hedges; the fields being divided by stone fences. This whole surface, inclined with many interruptions, is formed of the same kind of thin strata of *lime-stone*, with the fragments of which the island is entirely overspread; where they are the least broken, they are used for covering roofs. In various parts of the island, I have seen sections of the mass of these superficial *strata*, in the interior combes, and in the cliffs; this mass is four or five feet in thickness; and in a deep cleft, towards the upper part of the island, I observed below it about ten feet of a reddish *lime-stone*, extremely hard, which is blown up with gun-powder, because it cannot be hewn. Before the strata of free-stone are reached, various other kinds of strata are found, one of which appears to me to be marly; for when the surface of its strata has been exposed to the air, corrosion produces in it large *bosses*, sometimes circular, or semi-lenticular, and sometimes in different figures, as is often the case with those of stone-marl: I mention these strata particularly, because they will be found elsewhere, at a lower level.

498. The mass of *strata*, for which so many quarries have been opened in this island, is thus differently covered, and lies at different levels; it is about eight feet in thickness, and contains marine bodies of

various kinds. This is called *free-stone*, because it can be cut, and even sawn, in any direction: it is carried by sea to various parts of *England*, where it has been used in a great number of large buildings. Below these strata, there are others, to a great thickness, also of *lime-stone*, but not fit for similar purposes, being intersected with *siliceous* veins. Lastly, under all these *stony strata* there are *soft* ones, some of *clay*, others of *marl*; and among the latter, some are of *stone-marl*.

499. I shall stop here for a moment, because the phenomenon of *soft* strata associated with *stony*, of which an instance has been already seen in the promontory of *Weymouth*, and others will elsewhere appear, is very remarkable in *Portland island*. This phenomenon has been often opposed to the hypothesis which forms the foundation of the whole Huttonian theory; namely, the *consolidation* of our *mineral strata* by an *internal heat* of the globe; in particular I cited it myself in my Letters to Dr. Hutton, giving examples of it from *Jura*; to which Mr. Playfair has never replied. If there were an *internal heat* sufficient for the *consolidation* of the *strata* at the surface, why should it not have also consolidated the inferior *strata*, more immediately exposed to its action? I shall not repeat this remark, when the same phenomena shall present themselves in future; but it is time that some notice should be taken of so direct an objection. I must, however, observe, that it would be by no means an admissible answer, to

assert, hypothetically, that these *soft strata* are of a kind not proper to be indurated by *heat;* because this difference in the disposition of substances to *consolidation* is shewn by examples to belong to the theory of *chemical precipitations*, which is opposed by Dr. Hutton; and because the *clay* of these very *strata* is actually *indurated* by *heat*, when *bricks* and *pottery* are made of it.

500. The whole border of the island is interesting, when considered with respect to the catastrophes undergone by its strata. I have already said that it slopes down to the strand, in the part where the *Chesil bank* rests against it; while, immediately to the westard of this point, it is cut down abruptly, as is the case all the way to the lowest part on the south, where *caverns*, open to the sea, shew a phenomenon similar to that produced in mountains by a greater subsidence of lower masses of *strata*, when their fractures have not corresponded with those of the upper; and of this, examples in high situations will appear in these travels. The bottom of these low *caverns* of the island is not seen, being covered with gravel, accumulated on it by the waves: in the roof of one of them is an opening of several feet in diameter, and through this the waves at high water are seen to rush in, roll over the gravel, and break when they reach the extremity of the cavern.

501. This southern part of the island has not subsided equally: on the west, where the caverns are,

it is only about thirty feet above the sea; but on the eastern side, there has remained a promontory of considerable height, whereon one of the light-houses is placed. In returning northwards on this side, where the island preserves a certain elevation, a symptom appears of the catastrophe which formed the bed of the sea; this symptom is similar to some described in my *Elementary Treatise* around the *lakes* and along the *vallies* of *Jura* and of the *Alps*, evidently shewing the character of that catastrophe whereby those cavities were produced: and it consists of detached masses of the strata, which, in their subsidence, remained at a higher level, inclining towards the space where the rest of the strata disappeared. In this part of the island, the detached masses dip rapidly into the sea, their separation from the original mass producing a glen above them. On this coast there is an old castle, built on a cape at one of the sides of a great interior *subsidence*, which forms a *combe*, extending a considerable way into the island. The *strata* of this cape dip into the sea, thus turning their section upwards. Mr. Penn has built a handsome house on the opposite cape; and as the lower part of this combe is the only spot in the island where moisture, favouring the growth of trees, has produced a small wood, the place has been called *Pennsylvania;* it having been an ancestor of Mr. Penn's in whose honour that name was given to one of the American provinces.

502. Along this coast northwards is the way to the highest part of the island. I have examined this part on its summit, its declivity, and the coast below; and from its aspect in all these points of view, the catastrophe, which, at the epoch when the bed of the sea was formed, produced this *island* near the coast, may be as clearly understood, as it could have been by an eye-witness. In the *subsidence* of all the broken *strata* on that side, the part close to the fracture sunk only so much as to discover, more or less, the section of the *strata* of *lime-stone* remaining higher; and in some places, the *strata* of *marl* are discovered also. As for the slope below this section, it has absolutely the appearance of a chaos; it is composed of hillocks, formed by masses of the *strata*, which, in their fall, were so much broken and mingled together, that the stony masses have almost entirely disappeared: small pools are formed in their intervals, the water being retained on masses of marl or clay; it would even be impossible to walk over this space in rainy weather, on account of the soft state to which these masses are then reduced. When, through all this disorder, the sections of the *soft strata* of the mass of the *island* are found any where open to view, their species are seen to correspond with those of the cliffs of the promontory of *Weymouth*. These exterior *hillocks* rise, in some places, nearly to the height of the section of the *lime-stone strata* which command them; but as I passed over them following this section, I came to a part where I saw under it that of the strata of *marl;* they are

bluish, and among them are some of a yellowish *stone-marl*, great fragments of which are scattered over the slope; and on several of these I saw impressions of large *cornua Ammonis.* In some parts of the base of this amphitheatre, great masses of *marl* present to the sea the plane of their strata; but nearer the *Chesil bank*, a strand has been formed of sand and of a gravel composed of fragments of the lime-stone; and this, gradually widening to the point where a fort is situated, leaves a creek behind it, towards which the *Cheail bank* descends.

503. I have said that this bank begins close to the island, at a point where the latter descends in a slope down to the strand which borders the former; the village of *Chesil* being there situated; and that, by a section of the *slope* on the west, it is seen to be composed of fragments. There is a similar section of the same slope on the east, towards the side of the island just described, the upper part of which commands the confused assemblage of its hillocks. Now the latter section again shows the nature of this projection of the island, composed throughout of the fragments. I have said also that the sea is very deep on the west of the *Chesil bank*, while, on the east, its strand extends under the water with a gentle declivity. Such are the circumstances which have led me to the determination of the nature of the *base* of this bank, concealed from view no less by the sand of its strand, than by the enormous accumulation

tion of its gravel; and this determination I shall now more particularly state.

504. In the subsidence of the *strata* around the great mass of rocks, a ledge of them, extending itself to a great distance from the island, remained near the surface of the water, being cut down abruptly to the west, and gently sloping towards the east. On both sides of this submarine *bar*, the fragments produced by the rupture of the strata fell into the space now occupied by water; on the west, they disappeared almost entirely, the subsidence being there the greatest; on the east, the masses which sunk the least remained in disorder at a higher level: but at the point where the ledge above mentioned was left, near the level of the water, the fragments of the stony strata were stopped, and formed the *slope*, which, as I have said, begins from the highest part of the island, and which has, in the course of time, been covered with grass.

505. With respect to the formation of the *Chesil bank* on the edge, abruptly cut down, of this submarine bar, the first object of research is the source of the gravel which composes it; and this leads us to consider the hills extending themselves from the promontory of *Weymouth* in a north westerly direction, and forming the coast of *West Bay*. All these hills are covered with gravel of the same species as that of the *Chesil bank*; and their aspect towards this bay, as well as their surface, shows them to be only the disorderly remains of the strata, which, by

their subsidence, have here formed the bottom of the sea, covered, consequently, with gravel in much greater abundance than that of *Weymouth bay* to the eastward; the skirts of which, composed of hills of a different kind, I shall elsewhere describe.

506. The sea being very deep to the west of this submarine bar, which begins from the island, the waves beating against it on that side, have cast up the gravel on its edge, thus acting from below upwards; and as, during tempests with high tides, they have thrown the gravel much higher than the original edge, it has by degrees accumulated there. This *beach* would acquire a much greater breadth, were it not for the waves of the storms from the east, which, rolling over a strand with a slope scarcely sensible, drive before them all the gravel in their way, as far as they can extend, leaving only sand behind them. It is thus that the *Chesil bank* has attained to its present height and breadth; and from an anecdote which I shall relate in the sequel, it will be seen that this has been effected gradually. The eastern base of the banks is still gaining in extent, because great storms from the west, during high tides, continue to cast up gravel over it; as is shown by the crabs and shells found scattered on its top: its western rapid declivity is even formed into a kind of steps, marking the points to which the waves, when remaining for some time at a certain height, have carried the gravel. But on the eastern side, where the shore is open, (before the *Chesil bank* approaches very near the hills,) the gravel forms

shifting terraces of considerable size; the highest of these showing the point attained by the waves of the last tempest from the east during high water.

507. The alternate effects of storms from the west and from the east, modified by the form of the coast, have so exactly compensated each other in determining the height of the *Chesil bank* throughout its whole extent, that, as I have said, it might be taken for one of the great dikes of *Holland*: its summit cannot be walked on long, because before the few plants which grow there have time to bind the gravel, and to produce on it vegetable earth, the process is disturbed by the addition of fresh gravel; the stones, therefore, are almost every where quite loose, and in consequence extremely fatiguing to the feet: however I have walked over some part of this summit, which is very flat and wide; and there are but small inflections in it.

508. This bank is composed of *silices*, of the same kind with those scattered over the neighbouring hills, very different from the *flints* actually contained in *chalk*; the masses are oval, and for the most part have little or no transparence, though here and there occur some as transparent as crystal; but they exhibit no fine colours, except in that part of the bank, where, as I shall describe, they become extremely small. These *silices* are deprived by attrition of their natural crust; but it is retained by many of those on the hills.

509. A very remarkable phenomenon, with regard to the arrangement of the gravel in the *Chesil bank*, is the relative proportion between its difference in size, and its distance from *Portland island:* near *Chesil,* it is as large as a hen's egg, and some of it even as those of a swan; but from this point it progressively diminishes; so that, near *Abbotsbury*, it is only of the size of horse-beans, with little intermixture of any larger masses. Most of these small silices are semi-transparent; and some of them are of such beautiful colours, that, by the art of lapidaries and jewellers, very pretty necklaces and bracelets are made of them. Farther westward, this gravel still continues to diminish; so that at *Burton clift*, not far from *Bridport*, where the *Chesil bank* is at last united to the coast, the same silices, thus finely coloured, appear to be nothing more than coarse sand. In passing over the tops of the hills and their combes, I have found the gravel to diminish also in size from *Wyke Regis* to *Abbotsbury;* but by no means with the same regularity as in the *Chesil bank*, where the shades of this diminution are imperceptible.

510. It appears then that this singular difference in the size of the gravel proceeds in part from the position of the coasts. The waves produced by the N. W. winds, being the strongest, are thrown, when repelled by the distant capes, towards the projecting isle of *Portland*, and the beginning of the *Chesil bank;* and these waves are capable of driving before

them the largest masses among the gravel which they find on the bottom of the sea in *West bay*. In proportion as the other waves, more or less repulsed by the coasts, are inferior in force, the gravel cast up by them against the *Chesil bank* becomes less and less in size. Lastly, all the more considerable masses having been thus carried away, nothing remains on the bottom but minute gravel, and coarse sand formed by attrition, which are carried towards *Burton cliff* and *Bridport* by the currents of the tides. This is what appears to me the most probable; but, in general, the distribution of the gravel according to its size, not proceeding entirely from its original difference on the bottom of the sea in the bay, must be partly the effect of some mechanical operation.

511. I have but another circumstance to add, respecting this whole assemblage of phenomena; and it is one which is recorded in the county by tradition. In ancient times, great tempests, in a particular direction, pierced through the *Chesil bank*, carrying away the *gravel* at certain points down to the *base*, which was found to consist of *clay*. Now there are *argillaceous strata* in the hills of this coast, and even in the base of *Portland island*; and these accidental ruptures in the bank of gravel have shown that the *submarine bar*, whereon it is accumulated, is composed, at least in part, of these *argillaceous strata*, which have here subsided. When these accidents happened, it was unnecessary for art to interpose to repair the bank: such breaches, indeed, were of very

little consequence; they did not interrupt any road, for none could be made along this accumulation of loose gravel, and the opening communicated only with the *æstuary*: it was therefore abandoned to natural causes, and by these the breaches were soon filled up. At present, by the long continuance of the same operations, the *Chesil bank* is become so wide and so high, that no repetition of such accidents can henceforth take place.

Excursions on the Hills which border the CHESIL BANK.

512. It has been chiefly with regard to the *Chesil bank* that I have been obliged to collect under the preceding article, circumstances which I had observed at various times, in order to give at first a general idea of this phenomenon, (so nearly connected with those of *Portland island,*) and of its causes. But with respect to the latter, details are of great importance, on account of the theory of the actions of the sea on its coasts, which have been so differently considered in different geological systems; to these details, therefore, I now proceed.

Sept. 23*d.* 1804. I was accompanied in the first of my excursions by the Hanoverian Colonel (now General) VON DECKEN. We set out on foot from *Weymouth* at eight in the morning, and ascended first the hill towards *Wyke Regis*. In this road we had on our right the *back-water*, separated from the sea by the point of land on which is built the small town of *Melcomb Regis*. This whole assemblage of objects well deserves a particular description, which I shall give hereafter.

513. Having reached the church of *Wyke Regis*, we went on, through a *combe*, down to the *æstuary*, which is bordered by the *Chesil bank*, and towards which these hills descend; and we then proceeded along a *strand* at their foot, as far as the tide, then high, would permit. The upper part of these hills consists of strata of *lime-stone*, those of *clay* forming their base; and on coming to the bottom of a small *combe*, we found there the *stratum* containing the large *concretions* in the form of flattened spheroids, checquered with veins of spar. In some of these concretions, the columns, which have the appearance of being covered with yellow wax, are sufficiently separated from each other by the shrinking of the clay, to have beautiful radiated crystallizations of white spar, formed between them: these columns are properly the *Ludus Helmontii*. Here again, the *clay* containing these concretions made no effervescence with aqua fortis, while that of the *concretions* themselves effervesced very considerably. (§. 490.) On one of these masses, I saw the impression of a large *cornu Ammonis*; but I found neither that shell nor any other in the clay of the stratum, where their substance appears to have been consumed.

514.

514. The waves at high water, entering the *æstuary* as far as this point, still attack in some places the foot of these hills, and produce new falls of their materials, which they dilute and disperse; and this prevents the cliffs from being reduced into slopes and covered with grass; but higher up, they have been effaced by that process. The aspect here presented by the *Chesil bank* is very striking: it extends itself regularly on the same strait line, while the opposite side of the æstuary, formed by the foot of the hills, is deeply indented by combes, whence issue only small rivulets proceeding from their springs. It is thus evident that the base of the *Chesil bank* is a *mass of strata*, which was separated longitudinally from the coast, and sank, before the masses remaining at a higher level underwent those angular movements, whence resulted the *combes*.

515. The height of the tide preventing us from following any further the border of the æstuary, we ascended the hill, and proceeded to the village of *Fleet* situated in a combe; then crossing another hill, we came to *Fleet House*, a gentleman's seat, around which a great deal of ground had been taken recently into tillage, as has been the case, within some years, in all the western countries. Beyond this house, on the border of the æstuary, and in the lowest part of the *combe*, rises a hill, which is almost an island; the tide encompassing it on both sides, and nearly meeting behind it, where a very low isthmus only is left The *lime-stone* prevails at the bottom of this *combe*,

and probably composes the insulated hill; but the *strata* of that hill could not be seen, it being entirely covered with grass.

516. From this spot we went up the *combe*, which ascends to the north east, and we reached a point commanding an extensive view of the *Chesil bank* and of its æstuary; the former passing westward near the mount on which stands *St. Catherine's* church, belonging to *Abbotsbury*, and extending beyond it till out of sight. This high part of the *combe* is covered with heath and furze, and a very thin turf, large spaces remaining quite bare; in these, the soil is seen to consist of hard foliated clay; and it seems as if it were gravelled with small *gryphites*, like those which I had found in some of the strata of the cliffs of the promontory of *Weymouth*. In one of these spaces, where the valves of the *gryphites* were separate, they looked like shells of pistachio nuts; in another place, many of these *gryphites* were entire, and some of them were an inch and a half in length, and a quarter of an inch broad at the hinge; but the greater part were smaller. Among these shells there was a great deal of *gravel*, of the kind found on the *Chesil bank*, and smaller than that which we had observed on the preceding hills; some of it being even as small as that of the bank near *Abbotsbury*.

517. At the top of this *combe*, we came into a new high road which was then carrying on from

Langton Herring to *Weymouth*, and which we took for our return. The commons in this part of the country having been divided for the purpose of bringing them into cultivation, a good road has become necessary for the carriage of manure, and of the products of the land, a part of which has been sold in order to defray the expence. We found the road already cut strait across the land still uncultivated, and labourers were at work in gravelling it. They were doing this with fragments of *lime-stone*, though we were still on the *argillaceous strata*; but as we proceeded up the road, which lay on an ascent, we observed at the top a deep cut made to soften the acclivity; and from the colour of its sides, we judged that the upper part of the hill consisted of strata of the former kind. We then fixed our attention on the road, and on the neighbouring grounds, endeavouring to find out the point of junction between the *clay* and the *lime-stone*; but in the part where, as we judged, this ought to have appeared, a thick loose soil, composed of sand and of siliceous gravel, prevented us from discovering it. When we had reached the top of the hill, whence it descends towards *West Chickeral*, we saw the ground opened in several places, for the purpose of taking out the stone used for making the road, which is there found near the surface. I observed in its strata a particular circumstance proper to be mentioned, because it points out the same strata when found on other hills, and likewise at a lower level; they contain abundance of large *cardia*, of which, however, the shell has been consumed, and nothing remains but the mass moulded within it, and the impression of its outside on the exterior mass: there were many of these nuclei of *cardia* among the stones broken for the road, besides nuclei of *chamæ* and of *tellinæ*, and some *anomiæ* with the shell preserved. In order to render this road firm and durable, they cover the fragments of lime-stone with a quantity of siliceous gravel, taken from the interior foot of the *Chesil bank*; whence having brought it across the æstuary in a boat, they convey it up several *combes* to the top of the hill.

518. After crossing several inflexions in these hills, most of which correspond with lateral *combes*, and again finding the *lime-stone* on the highest parts, we reached the last declivity, composed of strata of pure *clay* and *loam*, and extending as far as *Weymouth*; where we arrived at three o'clock.

Sept. 30th. The preceding excursion having made me desirous to extend my observations farther on the hills which border the *Chesil bank*, I again set out on foot from *Weymouth*, at nine o'clock, and went first to *Langton Herring*, where I arrived at noon, and after having rested myself for an hour, I continued my walk.

519. From all that I observed in this excursion, will appear still more evidently the confusion produced in the *strata* by the repeated catastrophes which they have undergone; for, after having crossed

the hills composed of *foliated clay* already mentioned, before I reached *Langton Herring*, I came to one the surface of which consisted of the same thin *lime-stone* strata as form the upper part of *Portland island*; and afterwards, beyond that village, I passed a lime-kiln, where was burnt the kind of *lime-stone* described above as used in making the road, containing the nuclei of large *cardia*. I then came into a wide *combe*, much ramified in its upper part, at the bottom of which is terminated the *æstuary* formed by the *Chesil bank*.

520. On the opposite side of this *combe*, behind an interrupted ridge of hills, *Abbotsbury* is situated. These hills divide the *combe* of which I am speaking from another to the westward; and are terminated by the mount, nearly insulated, whereon stands *St. Catherine's* Church. All the rivulets rising in the amphitheatre above this spot, and descending through various *combes* on both sides of *Abbotsbury*, arrived at first separately at the sea; but the formation of the *Chesil bank* having impeded their passage, they have united behind it in a small stream, which enters the *æstuary* at its present head. I say its *present head*, because it is easy to be seen, that, before the formation of this bank of gravel, there was here a small gulph which has been in part filled up by the sediments of the land waters and of the tides. The original soil of this *combe* at its extremity, being, to a great extent, very low, it is covered with fine meadows, where numbers of horses and horned

cattle are reared; but a considerable addition has been made to these meadows by those, easy to be distinguished from them, which have been formed in the part of the gulph now filled up, and extend as far as the foot of the *Abbotsbury* hills.

521. On the anterior edge of these meadows, a conflict takes place between the gravel thrown up by the waves and the winds, which, passing over the *Chesil bank*, extends its inner base, and the vegetation which is tending to overspread that base; the gravel here being already very small, as I have said above. This conflict extends even into the little vale dividing the *Chesil bank* from the foot of the hills; the gravel raises its bottom; and the brook, arriving from the *combes* on the west, and passing this way to the *æstuary*, preserves for itself a channel, only by means of its extraordinary swells.

522. The meadows continue to gain on the rest of the gulph; and here appears the difference, already pointed out in the preceding volume, between the progress of meadows on *peat*, near lakes and rivers, and that of such as are formed on *marshes*, which is the case with these. In the marsh meadows, no less than in the peat, the *reeds* lead the *van* in the encroachments of the land upon the water; and the sediments of the latter being deposited between their stalks, other aquatic plants soon grow also among them; principally the *conferva*, some *mosses*, *rushes*, *equiseta*, &c. But all these plants undergo the

putrid decomposition, which raises the bottom very little comparatively with peat, and the elevation proceeds almost entirely from the sediments of the waters, favoured by the plants. This progress is however very perceptible in the large pool, (the remains of the gulph,) which terminates the *æstuary*. Having ascended the *Chesil bank*, during the time of low water, I saw in this channel many sand-banks uncovered; its borders are brought nearer to each other by the new lands added to them, and extending themselves in the lower parts of the *combs*; and a man of the neighbourhood, whom I met there, told me that the steps of the progress were sufficiently sensible to have been remarked, in many places, by the old inhabitants.

523. While I was passing along the inner part of the bank, the sea was much agitated; and I felt a singular sensation in hearing so near me, and at my own height, the striking and breaking of the waves on the opposite side. I climbed on the bank, in order to observe these effects; and though the spray sometimes came over me, I could hardly quit the scene which there presented itself. It was really a strange and beautiful sight, when I stood on the exterior edge, to behold along that line, as far both ways as my view could reach, the waves arrive, rise, roll in various directions, foam as they met, and scatter showers like the clouds. The gravel sprinkled with these showers was also an interesting object; there were a few silices as large as those near *Port-*

land island; but the mass of the bank itself consisted of gravel of the size of horse-beans, exhibiting the most agreeable variety of colours. The view of this assemblage of objects, belonging to the *Chesil bank* and to the form of the coast made me resolve on another excursion; and, though I did not make it till the following year, I shall give it a place under the present head.

524. This spot afforded me also a spectacle of a different nature, which I shall describe though foreign to my object, because it may be interesting to some of my readers. The sea being rough, the large pool within was quite covered with water-fowls; abundance of wild ducks from the sea having entered it, and mingled there with tame ducks, and swans. I learnt that there was in this place a *decoy*, belonging to Lord ILCHESTER, who farmed it out; and as I was curious to see how it was managed, I went to the house of the man who rented it, from whom I obtained the following information.

525. There are a great many tame ducks in this pool; and though they can fly very well, they never quit it, because they make their nests among the reeds, where they find plenty of food, and care is taken to feed them when the water is frozen. When the sea is rough, the wild ducks resort hither to associate and feed with them. A brook, after crossing the meadows, enters, through the reeds, into this pool, which is, as I have said, the extremity of the æstuary, or the

remains of the ancient gulph. This part of the course of the brook is bordered with willows and alders; and these favour the growth of aquatic plants, among which, and in the mud, the ducks pick up abundance of water-snails and insects. An artificial canal, wider than the brook, and bordered in the same manner, communicates with the pool very near the part where the latter enters it among the reeds, but turns away insensibly in a different direction. At the end of a certain space, this canal is covered with a net, at first raised to some height above the water, but gradually lowered to its extremity, where it terminates in a purse. This canal is the part properly called the *decoy*; and it has on one side a fence of reeds, with a few openings, through which it may be observed.

526. The farmer led me to the canal, and explained to me its use. The wild ducks enter among the reeds promiscuously with the tame; and the former, following the course of the fresh-water, ascend indifferently the canal or the brook; but the latter either remain among the reeds, or pursue the narrower channel of the brook; probably because some of their number, having been previously frightened in the *decoy*, avoid it, and are instinctively followed by the rest. When the wild ducks are seen, from behind the fence, to have passed on a sufficient way under the net, a noise is made behind them, which frightens and drives them forward into the purse, where they are taken. While I was standing with

the farmer behind the fence, he warned me to be still, because a flock of ducks, among which he observed some wild ones, was approaching that part of the pool; but they presently turned, and swam a different way. The farmer, indeed, told me, that few wild fowl were caught at this season, there being still plenty of food for them along the borders and at the bottom of the pool; but that later in the autumn, and in the winter, abundance of them entered among the reeds, following the rills of fresh water.

Having staid long at this place, I had not time in the evening to go back any farther than *Langton*, where I passed the night.

Oct. 1*st.* In returning from this place to *Weymouth*, I took a road more distant from the sea, often crossing fields, that I might the better observe the nature of the hills. I thus reached, by a different way, the upper end of the large *combe*, at the bottom of which *Fleet House* is situated; and continuing to follow the heights, I crossed also the top of the narrow *combe* containing the village of *Fleet*; proceeding from hill to hill, till I came to that above *Weymouth*. If, in different countries, similar excursions had been made over hilly grounds, such phenomena as are here observed would have been found in various places, and many errors in Geology might have been prevented. If, in particular, the attention is fixed on those of the hills, where the *section* of the various kinds of *strata*, lying one on another, is seen in some abrupt part, from which may be learned in what order they were successively formed in a horizontal position, over a large space on the bottom of the ancient sea; when afterwards these different *strata* are found thrown, as it were, in heaps, so that entire hills are constituted by each species, the strange catastrophes indicated by this disorder do not permit the mind to rest on the idea that the action of *running waters* has been necessary to the formation of *combes* and *vales*. This will farther appear in the following descriptions.

Journey from WEYMOUTH *to the western part of* DORSETSHIRE, *and first towards the extremity of the* CHESIL BANK.

Sept. 3*d.* 1805. I set out from *Weymouth* for *Dorchester*, at ten in the morning. From the slip of land whereon stands *Melcomb Regis*, I ascended the ridge of hills against the lowest extremity of which it rests, and which separates two ancient gulphs; of these I shall speak on a future occasion. This promontory is covered, as well as many of the other hills on the coast, with a thick loose soil, containing the same species of *silex* as the *Chesil bank*, of which also is formed in part the beach extending itself in front of the two ancient gulphs. The *strata* covered by this loose soil towards the bottom of the promontory are of the same *soft* kinds as compose a part of the extremity of that of *Weymouth;* and here again these strata are covered higher up by those of *lime-stone;* an association which likewise appears immediately in some parts of the shore, where all the strata are inclined. In ascending this promontory, I came, after various inflexions, to a horizontal space, where is a village, the houses and inclosures of which are constructed of a *lime-stone* consisting of *thin strata;* these, from all that will appear in the sequel, lie under the *chalk* throughout this whole country, but with strange dislocations.

527. Here again the ascent became rapid, and for a certain way I perceived the same loose soil on its surface; but by degrees I observed in it many fragments of *chalk*, with the *flints* belonging to the latter; and at last I arrived on *chalk hills*, extending eastward to a great distance, as I shall shew in a future journey. In this elevated soil there are great inflexions; and the hollow parts are now become meadows, having been levelled by means of the rain-waters, which, before vegetation had covered the heights, brought down thence small fragments of chalk. Some of the slopes are cultivated, but most of them, as well as the summits, are covered with turf, which has no other soil than the *vegetable earth* produced by the decomposition of plants, and this rests immediately on the *chalk;* an evident proof, that, since vegetation has begun to overspread these eminences, they have not been subjected to that

general *erosion* which is supposed in the Huttonian theory.

528. *Dorchester* is built on the declivity of a *chalk hill*, which, with the country around it, I shall describe in the course of another journey. From hence to *Bridport*, the road for a long time passes over chalk hills, much intersected with *combes*. Cultivation has made but little progress on these hills, most of which are only downs grazed by sheep. In some places, the turf is formed on a loose soil of sand intermixed with silex; in others, there is nothing under it but the vegetable earth on the chalk. The slopes of the higher hills, and likewise those descending towards the *combes*, are differently inclined, some having gentle declivities, and others being abrupt; which shews the state of the interior *strata*; but this cannot be fully judged of externally, because, where they are not covered by the loose soil, the chalk is shattered, down to a great depth. I saw on these hills some *blocks* of a hard *sand-stone*, nearly approaching to *granulated quartz*; of which elsewhere abundance of *blocks* will be seen on *chalk* hills, though that stone does not appear in *strata* in any part of the country. In my *Elementary Treatise*, and in the first volume of these Travels, may have been seen the geological importance of this phenomenon of the *scattered blocks*; which will again be presented in the sequel under different forms.

529. As I proceeded farther, the space occupied by these *chalk* hills, hitherto very wide, began to contract itself; and on the side next the sea, I saw a considerable extent of lower ground, great part of which was in meadows: this is properly a large *combe*, wherein is formed the small river *Bredy*, the mouth of which I shall hereafter describe. When I began to descend towards *Bridport*, I found the *chalky* eminences more thinly scattered, and at last I came upon *lime-stone strata*, like those already described in the ascent from *Weymouth* to *Dorchester*. The whole country hence in view on the west, to a considerable distance, in which is situated the town of *Bridport*, is nothing but a congeries of low hills without order. The little river *Brit*, flowing on the east of the town, proceeds from a succession of vales extending to the north, towards *Beaminster;* and the *Simene*, another small river, arrives from the west, through a different succession of vales. The interval between these two systems of vales is a chain of mounts with deep separations between them, *Bridport* being situated on the mount nearest to the sea: beyond this, the two rivers unite, and thence continue their course, under the name of *Brit*, through a large vale, which terminates at the sea, at a distance of two miles.

530. Arriving early at *Bridport*, I went first to call on MR. FAWCETT, a clergyman of that town, to whom I had a recommendation from MR. GÜNDELE, Chaplain to the Hanoverian Legion; he answered

very obligingly the various inquiries which I made of him; and having obtained from him information with regard to the road to be taken in following the *Brit* to *Bridport harbour*, where it falls into the sea, I set out on foot on this first course of observations.

531. On quitting the town, I crossed the *Simene*, in order to follow the foot of the western hills, which turning eastward at their extremity towards the sea, form one of the sides of the harbour. Near *Bridport*, advantage has been taken of the breadth of the foot of the hills to keep up in two places the course of this little stream, that it may fall on the wheels of some mills; but below these, after it has joined the *Brit*, they wind together through a great extent of meadows, where the difference of the soils is clearly shewn by that of the herbage: on the *original soil*, descending to the level of the sea with a slope almost insensible, the meadows are very rich; but it is succeeded by a horizontal soil, which has filled up an original *gulph;* on this the herbage is of a different and very inferior kind; and at its extremity towards the sea, the waves have at last raised a *beach;* so that to preserve a port here has been a work of great labour: it has been necessary for this purpose, to dig a large basin within the beach, raising a dike on its opposite side towards the meadows, to secure them against the high tides, which otherwise would still inundate the whole space; and the *Brit*, which has prolonged its course through these meadows,

discharges itself at low-water into the basin by a sluice. This basin communicates with the sea by a channel which is cut for the ships across the beach, and has its sides secured by strong planks and piles.

532. This channel requires to be constantly kept open, even to a certain distance in the sea; for the waves and the tides are continually tending to fill it up, as may be easily comprehended by their operations on the exterior strand, to which I went, along the western bank of the channel; the tide was out, and within the channel on this side I saw the gravel accumulated even above the level of the water, no passage being left for ships but on the opposite side. I found the beach here very curious, it being, as it were, the last shade of the *Chesil bank;* for the strand itself is composed of a coarse sand of various colours, appearing to consist of minute fragments of *silices* of the kind above described near *Abbotsbury.* The last laminæ of the waves, at that time very small, in gliding, at different levels, proportionally as the tide retreated, over this strand, of which the declivity is inconsiderable, had, in a manner, sifted the sand, driving before them the largest masses. In the *beach*, formed by the larger waves at high water, the gravel, smaller in general than that of the *Chesil bank* near *Abbotsbury*, was of the same nature, with only a few masses among it of a larger size. On the strand near this, I saw some ridges of the gravel; in the upper ones, it resembled peas or lentils, becom-

ing gradually smaller in the lower ones, and in the ridge still reached by the laminæ of the waves, it was not larger than hemp-seed; the sand itself being like turnip or poppy-seed: in the sequel will appear the connexion between these circumstances and the *Chesil bank*, which commences at a small distance on the east.

533. The congeries of the mounts which divide into small vales the space, low in comparison with the high hills, wherein stands the town of *Bridport*, extends along the foot of these hills. The mounts on the east under the *chalk* hills, are composed, to a certain height, of the strata of *lime-stone* already mentioned: on the opposite side, and along the coast where these low hills are cut into cliffs, their strata are of a different nature, as will successively appear. I followed that day for a considerable way the cliffs to the west of the harbour, presenting the section of *strata* of a yellowish *stone marl*, which, being unequally hard, and deeply excavated in the softer parts by the atmospheric actions, gives to the cliffs a truly grotesque appearance. Large masses of these *strata* have fallen down on the strand, where their differences may be distinguished by various characters, and chiefly by those of the marine bodies contained in them. I saw some masses which enclosed large bivalves, *ostræ*, *pectines*, *chamæ;* in others I found only small shells, of several species; and there was a third sort containing abundance of *belemnites.* These *strata* are deeply inclined, rising towards the

sea; they have also a lateral inclination, so that the lowest pass successively beneath the strand; and this is repeatedly the case with the same strata; for, after a fracture, they appear again at a higher level, and even with differences in their inclination, according to the breadth of the fracture.

534. Continuing to follow the strand, I suddenly perceived a great change in the *cliff*, little indicated by the inflexion of its summit. The *strata* were no longer of the same species as in the preceding part, with respect either to their nature or their colour: instead of the yellowish *stony strata*, I now found *soft strata* of bluish *marl*, intermixed with *hard* ones of the same hue; a frequent symptom, no less than the difference of *inclination*, of the great catastrophes whereby, on the borders of the new continents, the *subsidence* which produced the present bed of the sea was accompanied. Here also I found on the strand many masses fallen from the different *strata* of the latter *cliffs*; on looking in these for marine bodies, I could not find any in the soft masses; but in the hard strata there were quantities of small bivalves of various species; without doubt these shells, preserved in the latter by petrifaction, had been consumed in the former; a case very frequently occurring. Among the hard masses, there were some containing many bodies, which, at the first glance, I took for *echinites*; but, on a nearer inspection, I found them to be *fungites*. These *cliffs* are still crumbling down, because, notwithstanding the breadth

of the strand, the waves of the high tides attack their foot, diluting and dispersing all the soft or soluble masses, which are afterwards carried by the currents into the neighbouring coves; so that the materials falling from the cliffs cannot yet form slopes against them, and acquire a grassy covering. But the strand will continue to gain in height by the accumulation of the remains of these masses, with the gravel and sand brought up by the waves from the bottom of the sea; and the masses which shall continue to fall, will then rise against the cliffs, and secure them against farther demolition.

535. Going back to *Bridport harbour*, I thence returned to the town, where I arrived at six o'clock. I spent the evening at Mr. Fawcett's house, where I met an agreeable party, from whom, before I retired, I obtained sufficient information with respect to the farther observations which I intended to make. I destined the following day to the purpose of observing the eastern coast, passing over the hills on its border, and thence descending towards the strand, where the *Chesil bank* begins. With this view, I wished to hire an one-horse chaise; but Mr. Fawcett having been so good as to send his servant to inquire for one, without success, I determined to make the excursion on foot.

Sept. 4th. I set out from *Bridport* at nine in the morning, and crossing the vale, I followed the foot of the eastern hills as far as the part where I was to pass over them to the village of *Burton Bradstock*, at the distance of three miles. The slope of these hills (as is the case with most others of the same kind consisting of *stony strata*) is divided into terraces successively lower than each other, produced by the *subsidence* of the separated masses down to the point where, arriving at the lowest level, it has left the vacancy constituting the vale. On these slopes, as I have already often remarked, are commonly seen *sections* of the *strata*, above the masses which have thus sunk gradually more and more to the lowest point. The *strata* on this hill are very different from those described as forming the *cliffs* on the coast; they are of a hard *lime-stone*, which is broken for gravelling the roads, and I found in it the same shells as in the cliffs bordering one side of the *back-water* at *Weymouth*; these were chiefly small *chamæ*, with only the nucleus remaining, and small smooth *anomiæ*, with the shell preserved.

536. Following the foot of the hills in a direction towards the sea, I came to the lower end of a *combe*, which I ascended, and thus reached the upper part of a branch of these hills; then descending again towards *Burton*, I saw that village situated at the bottom of a wide vale, whence issues the small river *Bredy*. The hills being nearer each other in the part where the village stands, advantage has been taken of that circumstance to raise by a dam the level of the river, and procure a fall for mills. Beyond this, in its course towards the sea, it passes through

meadows, formed, like those of the decoy near *Abbotsbury*, in a part where a small gulph has been filled up, and a *beach* since raised in its front. Here, properly speaking, the *Chesil bank* begins: it is not so high in this part as at *Abbotsbury*, because the gravel is so small, that the wind easily carries it away, and sprinkles it over the meadows within. This gravel is too loose to impede the course of the *Bredy*, which has cut a passage through it, fifteen feet in depth from the top of the bank. The intersection has many windings; and as the tides formerly entered it, and spread themselves over the inner grounds, it then shifted very frequently. Meanwhile the ground within was raised by the sediments of the tides and the land-waters, together with the gravel carried thither by the winds, and was converted into good meadows, which it became an essential object to guard against the spring-tides. The interior opening of the passage has been therefore secured by a wall; and there is a sluice, which is kept shut when the tides are the highest.

537. It is necessary that the land-waters should be thus carried off from this space, because, as it is confined between two ridges of hills, they cannot, like those farther to the eastward, run along on the inner side of the *Chesil bank*, to discharge themselves into an æstuary. These two ridges of hills, one on the west, which I had crossed in coming from *Bridport*, and the other far to the east, descend from the foot of the *chalk* hills, and are both composed of

lime stone strata, to within a certain distance of their extremity; but they do not terminate with the same *strata* at the sea. I shall describe hereafter the extremity of the ridge which ends on one of the sides of *Bridport harbour*, where it is composed of yellowish *stone-marl;* while the extremity of the eastern ridge, to which I came in following the strand on the outer side of the bank of gravel, consists of strata of bluish *soft marl*.

538. This is *Burton cliff*, the point considered as the limit of the *Chesil bank;* because here it ceases to be insulated, and is united with this cliff, its length from *Portland island* hither being fifteen miles. But we have seen that it is again insulated to the west of this cape, and continues so to the cape which projects on the east of *Bridport harbour;* and the *gravel* of the beach formed before that harbour still partakes of the same nature, and is there at last reduced to coarse *sand*.

539. *Burton cliff* is high in the middle, and slopes downwards on both sides, but more insensibly on the eastern: it is still crumbling down, because the masses of marl which fall from it on the porous base of the *Chesil bank* are there diluted by the rains, and filtrate through the gravel to the sea. This is a remarkable circumstance in relation to the age of our continents; for I think I have sufficiently shewn at the beginning of this volume, and it will, in the sequel, still more clearly appear, that the notion of partial

elevations of the coasts at different periods is an absolute chimæra. This cliff was exposed to the attacks of the waves, from the birth of the continents, till the formation of the *Chesil bank*, by which it is now secured against that cause of destruction; but its degradation is still produced by the rains and the springs. Now the whole result of these operations, from the period of their commencement, is, that the bank has become at this point a little wider, because the winds and the waves cannot drive the gravel beyond the cliff.

540. The masses of the *marly strata*, which have subsided, may be seen to form here the base of the *Chesil bank*: these strata, descending towards the east, pass under the gravel, their lower part being covered with it. Their slope having little rapidity, I ascended by it to the top of the promontory; and this, when I had arrived at a certain distance from the sea, I found to be composed of the same *strata* of *lime-stone* as that over which I had passed in coming from *Bridport*. Hence, at a great distance to the east, I saw *Abbotsbury* castle, standing on one of the mounts belonging to the chain of hills mentioned in my preceding excursion. The interval between those, and the hills on which I now stood, was occupied, in the part most distant from the sea, by an amphitheatre of other hills, rising up to the eminences of *chalk*; the waters of the latter hills being prevented by the *Chesil bank* from reaching the sea, and forming, on its inner side, the small stream,

which, passing between it and *St. Catherine's* mount, enters the æstuary, and is thus carried into the bay on the east. I continued to ascend the ridge of hills terminated by *Burton cliff*, to the point where it joins the hills parallel to the coast, descending also in an amphitheatre towards the head of the filled up gulph, in front of which begins the *Chesil bank*: behind these, and between them and the eminences of *chalk*, lies the large vale, whence the *Bredy* issues. These hills at the head of the small gulph have been also formed into *terraces*, one below another, by subsidences successively greater down to the level of the sea: in the *sections* of these *strata* above the terraces, I saw several quarries of the *lime-stone*.

541. I descended hence to *Burton*; and after having rested myself at this village, I followed the foot of the hills on the western side of the *Bredy* to their extremity, with which is united that of the part of the *Chesil bank* separated from the rest by *Burton cliff*. I crossed this bank, and went down to the strand, which there descends under the water with a very gentle slope. The tide being out, the strand extended itself to *Bridport harbour*, along the foot of the cliffs terminating this promontory. The last laminæ of the waves, then small, were playing on this strand; and it was very amusing to see these drive before them the minute gravel, variegated with so many fine colours, and leave it, as they retired, in ridges, little larger than cords. Passing under the *cliff*, I found it very different from that of *Burton*,

and also from the other, on the west of the harbour, which I had observed the day before; this, indeed, is formed, like the latter, of the section of *strata* of yellowish *stone-marl*; but here they are homogeneous; so that erosion has not produced in them those grotesque forms, which distinguish the strata of the western cliffs.

542. The beach, formed of the same small gravel, is much raised against the foot of the *cliff*, excepting at one point, where, as I have elsewhere mentioned, the *strata* which have sunk towards the sea have remained at the level of its surface; and where the waves, rolling over this hard bottom, do not permit the gravel to lie on it. I ascended this beach in various parts, to observe, as well the cliff itself, as the masses fallen from it, examining whether its strata contained any marine bodies; I found none, but a single *cornu Ammonis*; whence again appears the difference between these *strata* and those of the western cliffs. There is an inflection in the summit of this cliff, accompanied with a fracture from top to bottom, on the two sides on which the *strata* do not correspond, and are even very different. By this way I arrrived at *Bridport harbour*, and thence returned to the town, which I reached at seven in the evening.

543. I had formed a design to take advantage of my frequent residences at *Weymouth*, by visiting the whole coast of *Dorsetshire* and the adjacent country, and observing there the *courses* and *mouths* of all the *rivers*.

rivers. The object of my present journey was the western coast of this county, extending as far as *Lyme Regis*, between which place and *Bridport* the river *Char* falls into the sea, near the small town thence taking the name of *Charmouth*; whither I purposed to go the following day.

Sept. 5th. I set out from *Bridport* at eight in the morning, in one of the public coaches, for *Charmouth*, at the distance of six or seven miles. The road from the former town rises obliquely over the slope of the hills, in a direction towards the sea, but with frequent descents, as it crosses *combes* opening into the vale of *Bridport*: nor does it become more even, when it has reached the top of the hills, along which it passes at a small distance from the sea; for there also many *combes* are to be crossed, all terminating above the *cliffs* on the coast, and one of them being very wide. These hills, not placed in any order, are either covered with grass, or cultivated, so that their *stony strata* do not appear; their surface consists of a deep loose soil, showing *strata* of *sand*, wherever it is cut down to lessen the declivities of the road; the upper part being almost entirely composed of fragments of *flint*: these, however, differ sensibly on different hills, as might be seen by the gravel laid in heaps along the side of the road for the purpose of mending it; within a certain space, the flints in these heaps, where they were broken, had a yellowish tinge, and were mixed with earth of the same colour; but farther on, the fragments, which were larger, were bluish, together with the earth about them. At some distance, I saw, at different heights, the excavations whence both these kinds of gravel were taken.

544. From the last ridge of these eminences on the *Charmouth* side, there is a view of a spacious and beautiful vale, whence proceeds the small river *Char*. This low space is of the nature of many others which I shall have occasion to describe; seen from a height, they appear to be only plains slightly undulated; while, as we descend gradually towards them, mounts rise to our view, irregularly dispersed, and separated by small vales. These *mounts* are masses of the *fractured* and *sunken* strata remaining above the level of the rest, as is shown in all these cases by many signs; and here in particular, by the circumstance, that these mounts and the vales between them are covered with the same strata of sand and gravel which are found on the eminences and their slopes.

545. The coast here forms part of a bay, bounded on one side by the cape to the west of *Bridport harbour*, and on the other by that of *Lyme*. I went down immediately to this coast, following the left side of the *Char*, through meadows formed on the new grounds filling up a small *gulph*, which existed originally between the extremity of the hills just described, and those rising to the westward, and bordering the coast as far as *Lyme*. Some judgment may here be formed of this river *Char*, issuing from the

large vale of which I have just now spoken, and giving its name to the town of *Charmouth:* when I came to the *beach*, composed of siliceous gravel, and here bordering the meadows, I was to cross the stream, in order to proceed under the cliffs on the western side; and this I did almost dry shod, on the gravel through which it passes to the sea.

546. As it was low water, there was a wide strand uncovered below the *cliffs*, which extend as far as *Lyme*, at the distance of two miles; and along this strand I proceeded. These cliffs are the section of the strata forming, towards the sea, the lower part of the side of a ridge of hills, advancing from the west, and terminating at the small filled up gulph already mentioned. This ridge is almost as much elevated above the lower part of the wide vale of the *Char* on one side, as it is above the sea on the other; the town of *Charmouth* being built on a very rapid slope, turning toward the vale, at the extremity of this high ridge.

547. The above *cliffs* begin with the section of strata alternately soft and hard. The soft strata produce little effervescence with aqua fortis; the hard make considerably more, their consolidation having been effected by a calcareous substance. In the latter, there are *cornua Ammonis*, some of which are of considerable size; and many, not having been filled with the substance of the stratum, are lined internally with sparry crystallizations, often covered

with pyrites; as is discovered in their fractures, or when they are sawn across their concamerations. There are people who watch the crumbling down of the cliffs in winter, and search among the fallen materials for the fossils contained in them, and especially for these *cornua Ammonis,* which make a very ornamental appearance in collections. In the soft strata there are concretions, in the same manner as there are *flints* in *chalk*; both being parts of the *stratum,* transformed into hard masses by a substance, which, having been retarded in its circulation by some extraneous body lying in its way, has there combined itself with the substance of the stratum. In the *flints,* these extraneous bodies are often distinguishable, and are very commonly marine shells. The nucleus of the concretions in the soft strata of which I am speaking is frequently a *cornu Ammonis.* These concretions, lenticular in their form, falling from the cliffs when parts of them crumble down, are found on the strand, where they continue for some time to resist decomposition: with aqua fortis, they produce considerably more effervescence than the soft matter of the stratum; a proof that they have been indurated by the combination of calcareous particles with those of the clay. The shell is sometimes perceived at one edge of these masses, which, if then split by a blow with a hammer on the opposite edge, will on one side retain the *cornu Ammonis,* and on the other its impression. Often likewise, when nothing appears externally on these lenticular masses, *cornua Ammonis* are found in them, if they are split in the same manner.

ter. Few of these shells contain the matter of the stratum beyond their first compartment; the rest is filled with spar, and lined with pyrates.

548. One of the hard strata towards the top of the cliff has a very singular aspect, and might be taken for trunks of trees lying along: such pieces of it as are found on the strand seem as if covered with bark, and fulls of knots; but some concretions under other forms are similar to these in their exterior appearance. This surface, so much resembling bark, is, like the *crust* of the *flint*, the transition of the substance from the soft to the solid state; as is shown, in both cases, by acids, which, in the flint, attack the crust to a certain depth, but, in the above concretions, they spare the surface, though they attack the inner part. All these concretions, in the course of time, suffer decomposition on the strand; so that the formation of a permanent beach proceeding very slowly, as at *Harwich*, (§. 462.) the cliffs still continue to crumble down.

549. After a certain space, having passed in front of a fracture in the cliff where the *strata* are in great disorder, I observed them beyond that point to change their nature, and I no longer perceived among them the stratum, in which the large concretions have the form of trunks of trees. I found these new strata regularly parallel, hard and soft alternately, but sloping down westwards; so that as I went along under their foot in that direction,

I saw them pass successively beneath the strand. The point where this change occurs is still at some distance from the cape, which terminates the bay on the west; and I could judge that the latter had been left thus projecting, in the catastrophe whereby the cliffs were produced: for the shore, there extending under the water with very little declivity, is formed of the *strata* which then sunk. Having tried them with aqua fortis, I found that the hard strata made the greatest effervescence. On one of these, I saw abundance of white crescent-shaped spots, probably the section of some species of bivalve; but I could not detach any part of them from the mass: on another stratum, I perceived impressions of *cornua Ammonis*, some of which were eighteen inches in diameter; but I found only fragments of the nuclei.

550. The cape advances into the sea a considerable way, and is longitudinally divided by a *combe*, terminating in the bay. *Lyme* is situated at the bottom of this *combe*, the side of which, therefore, concealed from me the whole town, only the tower of the church appearing above it. When I approached this cape, I was struck with the appearance of disorder in its slope. The strata being softened by some springs issuing from this side, are broken into large masses; of these, such as reach the strand, being beaten and diluted by the waves at high water, give place to those which follow them down the slope; and this occasions new crumblings from above. The slope having thus been formed, in a manner, into

steps, I ascended it, the weather being dry, in the part where it was the lowest, and crossing its top, I went down thence into the town, through which flows a small rivulet descending from the combe.

551. I made acquaintance here with one of the inhabitants, who knows this coast very well, because he visits it, from time to time, in search of fossils, which he sells to the strangers who resort hither; *Lyme* being a place much frequented for sea-bathing. At his house I saw some find *cornua Ammonis*, sawn through the middle, and various other marine fossils, proceeding from the above cliffs, and other places. I questioned him relatively to the side of the hill which was crumbling down; as it appeared to me that this circumstance exposed to great danger the part of the town rising against it within the combe: he told me that this was really the case; and in order to give me a just idea of it, he very civilly walked with me that way. We ascended by the inner side of the combe to the top of the cliff; and I saw but a very narrow space remaining there between the church, which stands very little below it towards the town, and the side thus crumbling down. My conductor told me that he remembered this upper part a great deal wider; that there had even been gardens on it; and that all the ground lost here had detached itself by broad sections, which had successively slidden down the slope to the bottom. He related to me an accident of this kind that had happened in his own sight, and had nearly been attended with fatal conse-

quences to him. There had been for some time a longitudinal fissure at some distance from the edge; but, as it did not appear to make to any progress, nobody apprehended danger from it, and the foot-path was beyond it on the cliff side: one day however, as he was walking along that path alone, he felt the ground give way under him, and at the same time he saw a section of the part which still remained firm, rising, as it were, above his level: he had already sunk half his own height, when becoming aware of his situation, he threw himself with a spring on the upper ground, and ran immediately towards the town, whence he brought back with him the first persons whom he met. They arrived in time to see this mass descending gradually, still entire; but, on a sudden, it broke into pieces, which fell, one over another, down the the slope to the strand. He then showed me other fissures, similar to the above, in the remaining part; and told me that if no precautions were used, it would not, he was convinced, be very long, before the church itself would fall: adding that, in time, it would be followed by all the part of the town which rose on that side.

552. There might certainly be means of preventing these accidents. This side of the *combe* should be bored in a direction towards the town, in order to meet the springs, and to afford them an issue that way, that their waters might no longer penetrate the exterior slope. A wall should then be built at the foot of this slope, as strong and high as

that of the *cobb*, or mole, which forms a secure post on the continuation of the cape, at some distance from the town. The slope, having its foot secured by this wall against the attacks of the waves, would then cease to crumble down from above, and its surface would be rendered solid by the good turf which would be formed on it. But this could not be done without a great deal of expense; the present generation does not believe itself in danger; and generations consider but little the interests of those which are to succeed them. It is therefore very probable that, in the course of time, the part of the town extending up this side of the *combe* will fall; but there the demolition will cease; since the exterior slope, having then a gradual declivity down to the sea, will oppose an effectual barrier to its farther progress.

553. The hard strata of the long cliff are used at *Lyme* for building stone; for which they are very proper, as they are easily broken into parallelopipeds, a foot in thickness, and bear the air extremely well; but on the shore they are subject to decomposition; and after their fragments have been for some time exposed to be alternately covered and abandoned by the tide, they produce so good a lime for the purpose of building under water, that they are carried a great way by sea for this use.

554. As I was desirous to be acquainted with the hills above the *cliffs* extending along the coast to

Charmouth, I determined to return by that way; and having obtained the necessary directions, I set out from *Lyme* on foot at four o'clock. The turnpike road passes over these hills; but it makes a great circuit; and though at a certain point it must be joined, there are paths by which the distance may be much shortened. I turned into one of these paths soon after I had reached the upper part of the town, and followed it through some fields sloping down to the cliffs on the *Lyme* side; but after proceeding some way, I came to the part, where, as I have said, it is necessary to return to the high road, for the purpose of crossing a *combe* rapidly descending towards the coast. The fracture, which, in passing along the strand, I had observed in the *cliff*, and beyond which I had seen the *strata* change, is at the bottom of this *combe*. Now, when viewed from above, the *combe* itself is shown, by the state of its sides to have been produced by a fracture, attended with an unequal subsidence of the separated *strata*. To form the road, it has been necessary to make a great excavation in the hill at the top of the *combe*; where a section, forty or fifty feet in height, exhibits *strata* very different from those which appear in the *cliffs* at the foot of these hills: the upper ones are of a pure yellowish sand, covered, to the thickness of four or five feet, with sand of a different kind; the latter being mixed, like the superficial soil of all these hills, high and low, with fragments of flint in prodigious abundance. This part of the road is guarded by a strong railing on the side next the *combe*, which is quite a precipice.

555. Beyond this section, on the slope of the hills towards the sea, the high road crosses them, and descends on their opposite side towards *Charmouth*; but having seen a path over them on the side where I now was, I turned into it, and it led me to the brow of the extremity of the hills bordering the small gulph of the *Char*. Hence I had a view of all the cliffs as far as *Bridport harbour*, and of the hills above them descending towards the sea, and exhibiting the same phenomena as those over which I was now passing. They are composed of many terraces, one below another; and above each of these appear sections of the yellowish, and in some places red, sandy *strata*, showing the subsidence of the parts before them, down to the level of that great subsidence beneath the present level of the sea, which produced the *cliffs*. The form of the ground is the same on the slope of the hill whence I viewed this extensive prospect. I descended to *Charmouth* by a road obliquely cut; and notwithstanding the successive subsidences so manifestly shown here, I found the surface still covered, down to the bottom, with the same kind of flinty gravel. In my descent, I had a view of the meadows now occupying the place of the small gulph; and meeting with some country people on the road, I question them on this subject: from them I learnt, that, in rainy seasons, when the *Char* is swelled, if the sea is at the same time high and

agitated, these meadows are still subject to inundation; but that they are continuing to increase in height by the sediments of the waters.

Sept. 6th. I spent the morning in rambling over the country adjacent to *Charmouth.* At some distance from the lower part of the town, the *Char* is joined by a brook, issuing from a vale between the high hills bordering the coast, and the low hills dispersed over the whole of the wide space through which the river flows. Advantage has been taken of a part where the feet of these different hills approach each other, to raise the water of the brook, that it may fall on the wheel of a mill. I crossed this brook, and proceeded along a path over the nearest of the low hills; and after having walked for about an hour, I found myself on an eminence higher than any other within a considerable distance around. It would be difficult to find a country which afforded more agreeable walks. All the paths are through grass fields, crossing dales, or obliquely ascending small hills; so that the objects, distant as well as near, are continually changing their aspect. From the top of the eminence on which I now stood, I saw branches of the large hills around this lower space advancing into it, broken into hillocks; the whole of this cheerful landscape being interspersed with houses surrounded by trees.

556. It is thus that, in certain hilly countries, almost all the external marks of the great catastrophes,

trophes, which have given to the surface of the earth its present form, are obliterated from the eyes of the superficial observer; small asperities have been softened by the waters, and vegetation has thrown over the whole its uniform veil, which therefore must be pierced, if we wish to know the original state of the surface; but in order to comprehend what may be thus laid open to our view in one place, we must be assisted by observations made in others. In this spot, some rivulets, proceeding from the springs which shew themselves on the sides of the low hills, flow in the intervals between the latter, and *gravel* is found on their beds. Whence does this *gravel* proceed? If, with the view of discovering the nature of the superficial soil of the hills, the spots where the turf is broken are examined, it will be seen that they are everywhere covered with the same *gravel*, composed of fragments of flint, lying on a soil either sandy, or, in some places, argillaceous: it is not surprising, therefore, that there is *gravel* on the bed of the rivulets. But how does it happen that this *gravel* is thus found in places where it could not have been disseminated by any cause now existing on the continent?—that it even covers in the same manner all the surrounding high hills, and their slopes down to this lower space?—These first circumstances, well considered, lead necessarily to the conclusion, that the dissemination of so much *flinty gravel*, of which even the original source in the *chalk* does not appear, must have preceded the retreat of the sea from our continents, and must belong to the catastrophes and other effects produced on the bottom of the ancient sea. If, after this, the sides of the large hills be examined, indications will every where be found, in all the abrupt sections remarked in them at different levels, that the parts, now *low*, have become such by *subsidence*. In particular, I saw on the inner side of the hills bordering the sea, over which I had passed the preceding day, wide, abrupt, and deep clefts, which, not receiving any water in this position but that of the drops of rain, cannot have been produced by streams since the birth of the continents.

557. Having returned to *Charmouth* and rested my self there, I determined to walk over the ridge of the large hills in the way back to *Bridport*, in order to observe their *combes* more particularly than I had been able to do from the coach the day before. As I was beginning to ascend this ridge, I overtook a countryman, who was driving a cart the same way; and I kept pace with him, that I might occasionally question him with regard to what I should observe. On the slope which rose above the road, I saw some spaces newly brought into tillage, where the turf had been taken off from a soil of gravel and sand, like that of the low hills; and this turf was laid up in heaps, in order to be thrown over the land at the end of a certain time. My companion told me that it was some years since this kind of culture had been first used; and that, having proved very advantageous, it made farther progress every year.

558. When we were at the height from which, as I said before, the space where the *Char* is formed among small hills appears only a plain with some inflections, I asked the countryman whether that tract of land was distinguished by any name: he told me that it was called the *Vale*; that the soil of the low parts was very rich, but so soft, that the roads were almost impassable in winter, because the cart-wheels sunk into it; a character of alluvial ground produced by the overflowings of brooks: he told me likewise, that, at the extremity of the space within our view, this *Vale* turned round a promontory of the hills over which we were passing; he showed me the promontory at a distance, with the village of *Whitchurch Canonicorum* standing on it; adding that, beyond this, the *Vale* rose between the hills, nearly to the point whence they began to descend towards *Bridport*. When we came to the village of *Chidiock*, where the countryman was to stop, he made me observe that we crossed there a branch of the *Vale*. This is a *combe*, descending from above with very little declivity, and opening sufficiently towards the bottom to afford a view of the meadows of the large space of which I have been speaking. A brook, here called *Char* also, and descending into the *Vale*, flows through this village; and from the point where the latter stands, a large *combe* begins, and descending in a different direction, terminates above the *cliffs* already described on the west of *Bridport harbour*; a small rivulet passes along it, flowing in in some parts through meadows.

559. I reached *Bridport* at three o'clock; and having rested myself there for a little while after my morning's excursions, I took a chaise for my return to *Weymouth.* Ascending now the slope beneath the eminences of *chalk*, I was better able than before to observe the *lime-stone* strata forming their basis, and the successive *terraces* under their *sections* marking the different points of their *subsidence* towards the vale of *Bridport*. The *chalky* fragments, beginning to cover the slopes, every where conceal the point of junction between the *chalk*, and the *lime-stone*, on which, in this region, it rests; but the strata of the latter appear again on the slope towards *Upway* in the road to *Weymouth*, as they are seen in coming down from *Dorchester*. At the village of *Winterborne Abbas* begins a *combe*, passing by *Winterborne Steepleton* towards *Abbotsbury*; and another, descending to *Upway*, begins at *Winterborne St. Martin's*. Following the latter, I observed on the road many horizontal spaces, extending themselves laterally, the course of which is pursued by the spring waters, because their passage is barred by ridges of small mounts; and though between branches of the hills of *clalk*, these mounts consist of *lime-stone*. The chalky hills on both sides here descend to *Upway*, of which place I shall have occasion to speak in future; and thence I proceeded to *Weymouth*, where I arrived at nine in the evening.

560. The *Back-water* at *Weymouth*, of which I have already spoken, is a very interesting geological

object; and as I have frequently observed it, with all the circumstances belonging to it, I shall give a separate description of it, in the same manner as I have done with regard to *Portland island.* In this space, originally a *gulph,* now divided from the sea by a slip of land, the small river *Wey* arrives at the level of the ocean, and thus gives its name to *Weymouth.* But, before I proceed to describe these parts, I shall quote a passage from Mr. *Playfair,* p. 368, relative to this general object. "The *mouths* " by which *rivers* on bold rocky coasts discharge " their waters into the sea, afford a very striking " confirmation of the conclusions concerning the " general system of *waste* and *degradation* which " have been drawn above. At these *mouths* we " usually see, not only the bed of the river, but fre" quently a considerable *valley,* cut out of the solid " rock, while that rock preserves its elevation, and " its precipitous aspect, wherever it is not intersected " by a run of water. No *convulsion* that can have " *torn asunder* the rocks; no *breach* that can have " been made in them, antecedent to the running of " the waters, will account for the circumstance of " *every river* finding a corresponding *opening,* by " which it makes its way to the sea; for that open" ing being so *nearly proportional* to the *magnitude* " of the *river,* and for such breaches *never occurring* " but where *streams of water* are found."

561. If this were actually the case; if the *vallies* through which *streams of water* flow to the *sea,* and *the*

the mouths by which they *discharge* themselves *on bold rocky coasts* were really *nearly proportional to* their *magnitude*; these would be strong confirmations of Mr. *Playfair's* system: but nothing is more contrary to facts; and indeed it was this passage of his work, so particularly calculated to produce a strong impression on the minds of his readers, which engaged me to undertake these Travels, with the view of enabling myself to give *detailed* descriptions of the objects presented by Mr. *Playfair* under this *general* form: he cites, it is true, some particular examples on this coast of *England*, in *Devonshire* and *Cornwall*; and I shall extract what he says of these when, in the course of my Travels, I shall come to the places; but I shall previously have occasion to describe the *mouths* of many other *rivers*, not less interesting than those adduced by him, for the determination of this great point in geology.

Description of the ancient Gulph at WEYMOUTH, *called the* BACK-WATER, *and of the course of the River* WEY.

562. In the great catastrophe which produced the present bed of the sea, a mass of the sunken *strata* remained at the level of the water, and formed a bar before two gulphs, produced by the same catastrophe, with very irregular subsidences of the strata around them. This submarine bar, beginning from the foot of the hills on the N. E. of *Weymouth*, extends before these

gulphs, separated by the promontory already mentioned over which passes the road to *Dorchester*. I shall describe, in the sequel, the gulph on the N. E., when I shall proceed farther along the coast in that direction; for the present, I shall speak only of the other, which, at *Weymouth*, is called the *Back-water.*

563. This *submarine bar* has produced on a small scale, within a space of two miles, especially on the N. E. of which I am not at present speaking, a phenomenon of the same kind as the *Chesil bank*; the waves have raised the gravel on it to such a height as entirely to separate both these gulphs from the sea, which being shallow in front of the *Back-water*, this slip of land has been here much widened; all the gravel having been carried to its upper part by the waves, they have left on the side next the sea a strand composed of sand nearly pure, extending under the water with little declivity, and becoming very broad when the tide is out: hence it is that *Weymouth* is so much frequented for sea-bathing; because, besides that it is always easy, with a horse, to draw the bathing-machines as far into the sea as is necessary, this strand affords a very agreeable ride or walk for those to whom the sea air is salutary.

564. It is on this part of the beach that the small town of *Melcomb Regis* is built; and by the *wells* made there, the *base* on which this beach has been formed is known. Those who sink these *wells*, first

dig through the gravel and sand accumulated by the waves; and immediately below these, they come to the same soil that covers the hills and the promontory beween the two gulphs; namely, sand of a different kind, mixed with gravel: in this is found the *fresh water* descending from the hills, and retained by the continuation of the *argillaceous* strata, which appear in the promontory below those of *lime-stone*, and which I shall soon more particularly describe. This is the same indication of the prolongation of the *continental soil* beneath the waters of the sea, as was found in sinking a *well* at *Amsterdam*, (described in my first geological work;) where, after digging through a great thickness of new ground, composed of sea-sand, and the sediments of land-waters, the *original bottom* was reached, consisting of the same sand with the surrounding hills; and there was found *fresh-water*, following the sandy strata.

565. At *Weymouth*, the tides ascend into the enclosed space through the channel in which the port lies; and before they can return by this narrow passage, the greatest part of their mud is deposited within, especially when the sea is agitated without; and, from the same cause, the sediments of the land-waters have also been mostly detained here. By these means, this original gulph is already so far filled up, that, as soon as the tide begins to retreat, islands covered with plants appear in it; and at low water, the whole space is dry, except the course of the *Wey*, and of some rivulets which here join it. The first

year that I was at *Weymouth*, a project has been formed of excluding the sea entirely from this space, by opposing a dike to the return of the tides, with a sluice to let the land-waters run off during the ebb: this would have produced a great extent of good meadow-land; but the execution of the project was prevented by persons better informed on the subject of ports; the narrow channel of this port absolutely requiring the return of a great body of water, in order to carry away the mud deposited in it by the ascending tides.

566. Nevertheless this space will be entirely filled up at last: for that which happens in all *æstuaries*, whatever be their breadth, is evidently here taking place; I mean that the sediments of the waters, as well of the sea as of the land, are the most rapidly accumulated at the most remote extremity; because, when the tide retreats, the water, in that part, only sinks, without having any current which can enable it to carry them along with it. Thus in the *Back-water*, at the point where the *Wey* enters, a great extent of meadow-land has been formed, and is still increasing. This is a great proof that the sea has not *excavated* the *gulph*, which it is thus tending, on the contrary, to fill up. The same proof exists in all gulphs, without any exception, to my knowledge, though I have observed a great number; and in most of them are found at the same time indications of the real cause of their production, namely, greater *subsidences* in the adjacent parts of the coasts,

mani-

manifested by the state of the *strata* on their borders. If I had made every where these detailed observations, they would have wearied my readers, and taken up too much of my time; but my different residences at *Weymouth* having afforded me the opportunity of making them around this ancient gulph, they may here serve as an example with respect to phenomena of the same kind on all coasts.

567. The promontory of the hills descending towards the slip of land occupied by *Melcomb Regis* is abruptly cut down on the side of the *back-water*; and with this part I shall begin my description of the circumferences of the last: it may be walked around at low water, except in the same places where there are streams. I have visited its various parts at different times, but I shall here give an account of the complete circuit.

568. On entering this space by the side of the above promontory, a large cliff first presents itself, exhibiting the sections of the *argillaceous strata*; the shore below it being formed of the same *strata*, containing large *gryphites*, and those *concretions* of a spheroidal form, which I have elsewhere described. Here again I tried these *concretions* with aqua fortis, in the *stratum* itself; on the *concretions* a great effervescence was produced, but none in the matter of the *stratum* around them. This cliff is succeeded by the lower part of the *combe*, beyond which the *strata* of a higher cliff show already some difference;

but a still greater appears after passing the bottom of another *combe*, at the point where the cliffs turn to encompass the head of the gulph. In this part the first cliffs, becoming gradually lower are composed of the same kind of *argillaceous strata*; but, instead of the large *gryphites*, they contain an immense quantity of small ones of a different species, such as I have already described, §. 516, but on the top of the hills near *Fleet*. Now at the low point of which I am at present speaking, as well as on those hills, the *lime-stone* strata succeed the *argillaceous*, without any change of level; for, as I followed this shore, after I had passed before an inflexion of the soil crossing the whole promontory to the opposite gulph, I found also the same *lime-stone* strata containing large *cardia* as I have described on the top of these hills. Here then we see an evident sign of *subsidence*; since the latter of these *strata* so well characterized, which, *on* the hills, cover in various places the *argillaceous* strata, are here by their side at the level of the sea, and even form its bottom in the gulph, where I saw them at low water, when I found abundance of nuclei of those large *cardia* on them as well as in the cliff, which was very low. We find, therefore, down to this level, the lowest of the continent, the effects of the *angular motions* of the *strata* during their subsidence, and the disorder resulting from those motions at all levels; and this serves us as a guide even beneath the waters of the sea, and leads us to comprehend on what base rests that abundance of *sand*, which, as I have explained in former works, and par-

ticularly

ticularly in the *Elementary Treatise*, §. 272, was the last of the *precipitations* produced in the *primordial liquid*. The hill above the latter cliff is composed of the same *thin lime-stone strata* which I have described at the top of the higher hills, containing nuclei of small *chamæ* and *anomiæ* with their shells.

569. After passing the village of *Radipole*, where the river *Wey* enters the gulph, and crossing over to the side opposite to *Melcomb Regis*, all the hills which form this turn have their upper part covered with fragments of the thin *strata* of *lime-stone*, while their foot at the level of the shore exhibits the *stratum* containing the large *cardia*. Then, beyond another *combe*, always a sign of rupture and subsidence in the strata, a great change appears. The bottom of this *combe*, into which the tides at first entered, has been filled up sufficiently to be covered with grass; and when I crossed it, a dike had been begun to enclose it, and prevent the return of the tides, with a sluice for the passage of a rivulet at low water. Now the opposite side of this *combe* consists of *argillaceous strata*, which likewise form the shore, and in which the large *gryphites* are found.

570. At the extremity of this low hill, the gulph, here turning towards the port of *Weymouth*, has for some time had a large space separated from it by a dike with a sluice. This space is covered with very good meadows; and the dike is in no danger from

the attacks of the exterior water, being protected by *fore-lands*, as, in *Holstein*, the new lands are called which continue to form beyond the dikes. This dike leads to the foot of the hills bordering the port of *Weymouth*, whence a bridge crosses over to the slip of land on which stands *Melcomb Regis*.

571. I have now to speak of the river *Wey*, which, as I have said, enters the gulph at the point where the village of *Radipole* is situated. There a valley opens, worthy the attention of Mr. *Playfair*; who may judge whether it is conformable with the idea expressed in the passage last cited. This opening, which was the *mouth* of the river to the *sea* before the *gulph* was separated from the latter by the slip of land of *Melcomb Regis*, is in an intersection of the hills of *lime-stone* bordering this part of the gulph; and the *valley* wherein the river flows extends itself above: let us then examine whether this *valley* and its *opening are nearly proportional to the magnitude of the river*; a point of which it will be easy to judge from the following description.

572. At *Radipole*, within the opening by which the *Wey* issues forth between the feet of the hills, here approaching each other, the *lime-stone* strata are abruptly cut off; so that the river would form a natural cascade, were it not that advantage has been taken of this circumstance to make it fall on the wheel of a mill. Above this opening, the hills on both sides, all being intersected with *combes*, retire back to a con-

a considerable distance, and in this manner encompass a large horizontal space, covered with meadows on an *alluvial soil*. The *river* has preserved for itself a channel in this new soil, which is seen on its sides; at the extremity nearest the gulph, the stream, when of its common size, flows about two feet below the level of the surface; but, in advancing up the *valley*, which is about four miles in length, this depth is found proportionally to increase: now in the whole space there are few parts where the channel of the river may not be leaped over.

573. Besides this natural channel of the *Wey*, an artificial one has been made, by which a part of it is led along the foot of the hills on its left bank, for the purpose of watering the meadows in times of drought: in observing the sides of this channel, it is seen to have been cut through the rubbish of the lime-stone which covers the higher slopes. The hills themselves furnish very little water, except in rainy seasons; there are only a few springs in the sides of their *combes*, and the waters of these are led to the river by small channels cut through the meadows; but many of them are dried up in summer, though during great rains, or when the snow is melting, these meadows are overflowed, and additions are made to the height of their soil by the fresh sediments deposited on it.

574. The slope of this wide *valley* is so inconsiderable, that art has been necessary to make the

river of any use for mills: there is one in the village of *Nottington*, to which the water is brought from a great distance in a canal cut almost horizontally along the foot of the hills, in order to produce a fall. Farther on in the *valley*, there is another mill of the same kind, on the right bank. Towards *Brodeway*, a village beyond this on the left bank, the hills on that side rise and acquire greater breadth, and a brook descends from them which turns another mill. The *valley* then contracts itself, till at last it terminates at *Upway* in a perfect *cul de sac*, being at this end encompassed with eminences. It is here that the river *Wey* has its origin; it issues from the foot of the hills, of which, as we have seen above, the bases consist of strata of *lime-stone*, and the summits of *chalk*. The two first branches of this river come out near each other, from the bottom of a slope of rubbish, where their issues are secured by brick-work; a little way below this, other similar springs arrive laterally to join these; and their waters are collected in an artificial reservoir, whence they fall on a mill-wheel.

575. I have now described the whole space through which the river *Wey* flows, from its source, till it arrives at *Weymouth*. I have entered into all these details, because this is a place very much frequented, and one that comprizes, on a small scale, almost all the phenomena observed on the course of the largest *rivers*, from their origin to their mouth; as will appear from my descriptions, though less circumstantial, of a great many other rivers, which discharge

themselves on this southern coast of *England*. I shall now resume the account of my travels, beginning with the other ancient gulph, already mentioned, on the *Weymouth* coast.

Excursion on the Coast near WEYMOUTH *to the East.*

Oct. 2*d.* 1804. Setting out from *Weymouth* at eight in the morning, I went first under the extremity of the promontory, over which lies the road to *Dorchester*. Beyond this cape, begins the part of the *beach* mentioned above as the most nearly resembling the *Chesil bank*, it being broad and high, composed of loose siliceous gravel, and rising as much above the lands enclosed by it, as above the sea at middle tide; from hence, this beach is extended a mile farther to *Straton point*, where the coast turns towards the east, following the direction of the hills which on this side border the ancient *gulph* now filled up.

576. No stream arrives within this space, which receives only the waters of some springs, and the rain-waters immediately falling here and on the surrounding slopes; these waters continuing to raise the horizontal soil by their sediments. This space is covered with grass throughout; but no good meadows are as yet formed on it, except round the foot of the hills; the middle part is still marshy, because the

earthy particles, washed down from the hills by the rains, are mostly deposited before their water arrives so far: I saw cattle, however, grazing in this space; but I do not suppose that they remain here during the winter season. The waters have preserved for themselves two channels across the beach, one towards its middle, the other near *Straton point*; these are secured by brick-work, and have sluices, which are kept shut when the sea is very high. All the extremities of the branches of the hills here terminating were cliffs, at the time when the gulph was first occupied by the sea; this is evident from their form; but they are now reduced into slopes, and covered with grass.

577. I entered this space by the side of the promontory which divides it from the *Back-water*. Along the foot of that promontory, I saw a ditch carried on in the line of its junction with the horizontal ground: here the original land is itself very low, and in meadows; and a small dike is formed on its edge, with the earth taken out of the ditch, probably to secure it from being inundated by the sea when, during tempests at the time of the highest spring tides, the waves pass over the natural dike of gravel on the coast: indeed it is evident that this sometimes happens, from the nature of the grass in the marshy part.

578. The side of the hill, which I was thus following, is at first composed of *argillaceous strata*, as well

as its opposite side towards the *Back-water*; but in these I found large *ostreæ*, with both their valves very flat, which are not in the *strata* on the other side; and this proceeds from the inclination of their mass, whereby different *strata* are brought to the same level. Here again I observed that change in the nature of the *strata*, which I mentioned in §. 569: the inflexion, there described as passing across the promontory, appears also on this side; and the hill rising beyond it, is composed of strata of lime-stone, as it is on the *Back-water* side. These hills encompass the head of the ancient gulph of which I am speaking, and descend, like the others of the same kind, in successive terraces. So that here, as well as around the *Back-water* every thing bears the impression of the angular motions of the strata, in the subsidence of these retreating parts of the coast; and this will be seen to continue along the exterior part.

579. The bank of gravel is very broad at *Straton point*, whence it is continued towards the east, forming a wide beach in front of the cliffs; these are at first low, and composed of strata of *marl*, in which I saw large *ostreæ*, with one valve concave and the other convex. Following this first part of the cliffs, I came to a cape, where, they rise to a greater height; the soft marly strata there pass under others of *stone-marl*, like those described §. 497, in the most elevated part of *Portland island*, and the strand is covered with the lenticular masses which are formed

by erosion in strata of that kind, and are from some inches to some feet in diameter. I ascended this cape, and in the projecting masses, I saw its *strata* descending behind, and rising towards the sea; they cease at a point where the cliffs are interrupted by a recess, called *Sutton boat cove,* because the neighbouring fishermen lay up their boats there. I went down to this cove, and then reascended on the east of it, where the cliffs begin again with the same *strata,* which, abruptly cut on the land-side, rise towards the east, according to the direction of the coast.

580. Proceeding along the top of this cliff, I found it cut off towards a *combe,* which extends itself some way inland, with all the marks of a partial *subsidence;* the masses of the broken *strata* descending in successive terraces to the beach, still very wide. I went down on this beach, composed of silices of the same kind as those of the *Chesil bank;* but all the different sizes, which I had found in regular succession on the latter, when I had followed it towards the west, are here mingled together. This gravel is sifted in a very singular manner: the waves, breaking on the beach, cast up its smallest masses on the rocks, the projecting parts of which retain them; and I saw in several places little heaps, appearing as if handfuls of the gravel of the *Chesil bank* near *Abbotsbury* had been thrown, or small baskets of it emptied there.

581. This beach ends near another cliff; and here the shore is formed of the planes of *calcareous strata* which have subsided, so that the gravel cannot lie on it: these strata pass under the water, with an inclination of about 45°: those in the cliff descend also towards the sea, but they incline more to the east, and are therefore seen to pass successively below the level of the strand. This is an inclination opposite to that of the strata in the cliff preceding the *combe* above-mentioned. Examining the *strata* in the cliff, as, in my way eastward, they successively came down to the shore, I could not, for a long time, find any marine bodies in them, though on the shore lay masses containing the same *chamæ*, with transverse tuberculated lines which I had observed at the extremity of the promontory of *Weymouth*, in the same kind of stone-marl: I did not at first distinguish the stratum whence these masses had fallen; but when at last it came down to the shore, I was able to follow it back with my eye in its oblique ascent to the top of the cliff, where it is cut off.

582. When I arrived at the point where those of the stony strata, which, in their formation had been the uppermost, disappeared under the shore, the borders of the sea offered nothing to my view but heaps of masses of foliated clay, fallen from a great height; and passing onwards, I came to a part where there had been such a descent of these masses, that they formed a cape, round which I could not have passed, had it been a little later, because the

tide was rising. Beyond this cape, the aspect of the coast was changed; the shore being so much covered with blocks of *lime-stone*, that I had some difficulty in following it: in these masses, I found all the kinds of strata which I had before seen in the cliff; but they could not now be distinguished above, as the cliff was here reduced into a grassy slope. A little farther, there is a part of the shore where the blocks are almost buried in a gravel composed of silices and calcareous fragments, like that at the eastern end of the *Chesil bank* near *Portland island.*

583. From this point, I saw to the eastward a cliff, in which the strata of *lime-stone* again change their inclination, rising from under the shore, and ascending towards the east; at some distance beyond, they cease, being abruptly cut off; and the following cliffs consist of *argillaceous* or *marly* strata. I was afraid that I should not have been able to go any farther along this coast, because the tide was already very high, and I had before me a promontory of these soft strata; it did not however, stop me, because the dryness of the weather permitted me to pass over some part of it; and beyond it, I perceived the most striking symptoms of great catastrophes. Such objects ought to be seen, in order that a just idea might be formed of the manner in which the *strata* were broken and overturned, on the borders of the new continents, when, by the subsidence of the ancient,

the present bed of the sea was produced: of this, however, I can give only a general idea.

584. There is, in this part, a great *combe,* where the different kinds of *strata,* overturned by subsidences successively more and more considerable, have changed their relative position from the top of the hills, down to the level of the sea. At the bottom of this combe there is another cove, where the fishermen lay up their boats; this is called *Osmington mill cove,* because a brook, which turns a mill at *Osmington,* formerly came to discharge itself here; but its course is now turned to a different part of the coast. I proceeded to the point where this brook falls, in a sheet of water, over the edge of a section of one of the *lime-stone* strata which I had seen in the preceding cliffs; this stratum contains large thin *ostreæ* and a quantity of *tubes* of *sea-worms.* This mass of *strata,* having sunk down, has been broken off in the front; part of it remains on the coast, where it ſhews its section; and the shore itself is formed of the part separated from this, its inclined strata passing under the water with many fractures; visibly pointing out what is become of the rest of these strata, which originally existed at a higher level, when covered by the ancient sea, namely, that it now forms the bottom of this part of the present sea.

585. Here I was at last stopped by the tide, ready to cover this shore composed of rocks, in some places

broken. I regretted it, because I saw to the east a higher cliff, the first part of which appeared to me to consist of the same strata of *lime-stone* as the spot that I had already reached, while a little way beyond, after an interruption, rose high *chalky* cliffs: in front of the former, the whole coast was bordered with large masses of stone. I could have wiſhed to observe the relative position of these two classes of strata; but the tide allowed me time only to return to the cove which I mentioned, in order thence to ascend to the top of the cliffs: there I fortunately met with a fisherman, who at firſt assisted me in climbing; but when he saw that I was fatigued and much heated, he invited me to rest and refresh myself at his house, which was at no great distance; I gladly accepted his offer, and he and his wife shewed me much kindness.

586. From this house I saw rising on the eastward, at some distance from the sea, a hill in the form of a cone, covered with grass, at the top of which I perceived some *chalk-pits*; and when, having sufficiently rested myself, I asked the fisherman whether I could reach its summit, he was again so kind as to go with me, and to show me the way to avoid a *combe* lying between that hill and his house. He then left me, and I ascended a slope forming several terraces, where the *strata* do not appear, because they are covered with rubbish and very thick grass; however I could distinguish the point at which the *chalk* begins, the grass being there much shorter, and the

acclivity more rapid. I went to some of the pits, where the *chalk* is dug for the purpose of being spread over the fields without burning, as is customary in this part of the country. I entered the deepest of the excavations, which was carried on to the *strata* themselves; but they were so much broken, that I could not judge of their direction. This mass of *chalk* has remained insulated in this manner, at a high level, because the rest of the mass composed of various strata, has subsided all around; the whole having fallen down in the greatest confusion. The top of this hill is of some extent; and it slopes downwards on all sides, especially towards the east, where it partly forms the side of a large *combe*, which, arriving at the coast, divides the cliffs consisting of the *lime-stone* strata, from those of *chalk* rising to a much greater height on the east: a brook, formed by the springs oozing out of the sides of this *combe*, flows along its bottom, and arrives at the sea in this wide interval.

587. Those who shall observe many coasts with an attention equal to that which I have bestowed on this, and shall consider every particular circumstance belonging to them, and to their connection with the neighbouring lands, will find it impossible to retain the persuasion that *vallies* have been formed by the action of *running waters*, and *steep coasts* by that of the *sea*; for they will perceive that all the phenomena of coasts concur in supporting the opinion that the present bed of the sea has been produced by the

subsidence of a great part of the surface of the globe, followed by different catastrophes on the borders of the parts becoming, at the same time, the continents; so that, whenever the original bottom of the new sea can be discovered, it is seen to be formed of the masses of the *strata*, which were broken off on its edge, and subsided to the nearest point of the new bed of the ocean.

588. It had been my intention to return to *Weymouth* over the hills at some distance from the coast; but it was too late for this when I came back to the house of the friendly fisherman, from whom I learnt that I should have nearly eight miles to walk that way; whereas it would be but four along the top of the cliffs, by a path which he pointed out to me, and which I accordingly took. I did not, however, give up my project of observing those hills, but reserved it for another excursion. The path shown me by the fisherman lay over the downs; but he, being himself accustomed to it, unluckily had not thought of the probability that a stranger might miss it: I found it very agreeable at first, and so it would have continued all the way, had not the night, which came on with a cloudy sky, proved very dark. With my utmost care I could then no longer discern the path, it being but little beaten; and wandering out of it, I came to many obstacles which embarrassed me. For a while, there were occasionally people on the downs, who led me back into the path; but having walked on for some time, as it grew later, without meeting

any body, I wandered so far out of the way, that I came to the edge of a precipice, which I perceived but just in time to save myself from falling down it. Not knowing then how to proceed, I had recourse to loud cries; and fortunately I was heard by a man, who answered them, hastening at the same time towards me: when he came up, I told him how I was circumstanced, and whither I wanted to go; and immediately, taking my hand, he led me by a very steep path, which I could scarcely distinguish, down a combe terminating at the shore; where he assured me that, as the tide was now out, I might proceed under the cliffs, without any obstacle, to *Straton point*, beyond which the road was known to me; we then wished each other good night, and parted, but without having seen each other's faces, on account of the darkness. From *Straton point* I had still two miles to walk, chiefly over the loose gravel; so that it was nine o'clock before I arrived at *Weymouth*. My plan having been to visit all the eastern coast of *Dorsetshire*, I executed it in two different excursions; undertaking the first of the sea few days after the walk which I have just related.

Journey from WEYMOUTH *to* LYMINGTON *and the* ISLE *of* WIGHT.

Oct. 8th. 1804. I set out from *Weymouth* at ten in the morning, and my first stage was to *Dorchester*, at eight miles distance; because one of my views in this journey was to observe the interior course of the waters arriving at the sea in the parts which I designed to visit, namely, the eastern extremity of the *Dorsetshire* coast, where the gulph of *Poole* is, and that of *Hampshire* as far as the Isle of *Wight*; for the latter being an *island* near the coast, like that of *Portland*, I was desirous thoroughly to understand its nature, and its relation to the neighbouring land. I have already described the ridges of hills from *Weymouth* to *Dorchester*; I shall therefore begin my account of this journey at the latter place.

589. The town of *Dorchester* is built on the slope of a *chalk* hill, descending down to the edge of a large vale covered with meadows, through which passes the small river *Froome*, continuing its course by *Wareham*, into the gulph of *Poole*. That the above *vale* has not been excavated by the *river*, is here very evident; the meadows being in this part so wide, that, from a great way above *Dorchester*, the stream divides itself into two branches; one of these passing along the foot of the hill on which the town stands, and the other near the opposite hills at a considerable distance. I saw the water here very limpid, flowing over a gravelly bottom, covered with aquatic plants, an accumulation of earthy particles on the gravel appearing on the sides of the current; which is the case with the beds of all rivers preserving their courses through their own *alluvial soil*, as will be seen from other examples: this stream is subject to great overflowings, because, in its common state, it is

formed by the springs oozing from the slopes turned towards it of a great tract of hills; so that, after long rains and the melting of snows, all the additional waters run down those slopes into the various channels of the river. From this, however, nothing more has ever resulted than the elevation of the soil throughout the whole extent of this wide vale, which, at such seasons, becomes like a lake, wherein all the earthy particles brought down by these waters are deposited; the greater part of the current continuing to occupy only the channels within which it is at other times confined.

590. After having made these observations around *Dorchester*, I left it at three o'clock for *Blandford*, sixteen miles distant from thence. Most of the hills over which I passed are covered with a very deep loose soil, formed of sand mixed with siliceous gravel. On these appeared, as it does on all hills, the difference pointed out in the *Elementary Treatise*, and in the introduction to these Travels, with respect to the situation of the *gravel*, between the places where it has certainly been diffused by running waters, and those where it is found out of their course. In soils really composed of *alluvial* land, the *gravel*, as has just been seen, occupies the lowest place, and is covered by the sand and earthy particles; but on these hills it is constantly on the surface, or in strata interposed between others of pure sand; a circumstance which indicates a quite different cause of dissemination, and cannot have been otherwise produced

than by the agitation of the water on the bottom of the ancient sea. These hills are themselves of different natures; on some of them, this loose soil is very deep, and without any appearance of *chalk*; but, after passing many of this kind, I arrived on one, resembling those in the neighbourhood of *Dorchester*, where the *chalk*, coming up to the surface, is covered only with a thin turf on the vegetable soil. In various places where this surface was opened, I saw great quantities of flints, mingled with the *chalk* down to a great depth: the chalk is here taken out to be spread over the fields, and the flints are used for gravelling the road all the way from hence to *Blandford*; some of them are very large, and require to be broken for this purpose. I stopped at *Blandford*, and spent the night there.

Oct. 9th. I employed part of the morning in visiting the banks of the small river *Stour*, which discharges itself into the sea at *Christchurch* in *Hampshire*. This river flows by *Blandford* with a tranquil course, through large meadows, formed on a soil levelled by the sediments of its inundations; and the hills sloping down to these meadows are covered with wood: so that here is again a *river* which cannot be supposed to have *excavated* the *valley* wherein it flows.

591. I had travelled thus far in post-chaises; but, that I might be the better able to observe the country, I hired at this place an open one-horse chaise, with a guide, for the remaining part of my

way to *Lymington.* In passing over the hills, I had often again a view of the *Stour*; it has attacked, in some places, the foot of the hills on its borders, and has caused them to crumble down; but it has not transported to a great distance the earthy particles which it has thus carried away, for they have been deposited wherever it has found wide spaces in the vallies; and on these sediments are formed meadows, like those near *Blandford*: many of the cliffs, at first produced by this action of the stream, are now reduced into slopes, and covered with grass; and those still crumbling down will arrive at the same state, whenever, by their retreat, the river shall be enabled to take wider turns.

592. The hills along this road still belong, within a certain space, to the region where the *chalk*-appears, differing however greatly from each other, with respect to the quantity of the fragments of *chalk* and *flint* mixed with the loose soil of their surface: they terminate at the vale of *Wimborn Minster*; but before I came to that vale, I saw on the north the last of the *chalk* hills, which is a very remarkable one; this is *Bradbury ring*, rising in the form of a truncated cone, its broad summit being surrounded with a circle of eminences separated from the mass by a hollow interval of great depth. HUTCHINS, in his history of *Dorsetshire*, supposes this to have been a fort constructed by the ancient Britons; others think that it was a Roman camp, as the remains of many Roman works are found in the country. However

this may be, the hill itself cannot have been produced by any cause which has belonged to the continent since it has existed.

593. The small river *Allen*, falling into the *Stour* a little below this spot, follows at *Wimborn* the course of a large vale, which, being levelled by its waters and now covered with meadows, is crossed on a long causeway with many arches; the greatest part of these meadows being under water when the river overflows. Beyond this, I ascended some very barren hills covered with heath, where the turf is cut up, and used for fuel; and the ashes mixed with sand, remaining after it is burnt, form a very good dressing for the land. From these hills, I had a view of the singular *gulph* of *Poole*; and having passed over them, I descended into a large space below, where the soil, like that of the hills, consists of strata of sand, covered with siliceous gravel, and having *white argillaceous* strata lying between them. These low grounds terminate at the gulph of *Poole*; but the town of that name is built on a promontory of the same soil, nearly three miles in length. I shall not at present enter into a description of this gulph, because I returned hither the following year, to observe it more particularly; here, then, I shall only say, that, after my arrival at *Poole*, where I spent the rest of the day, I followed a slip of land beyond the town, where it becomes low and narrow; and passing before a row of houses, I stopped to ask for a little water from a well which I saw there, and found

it very good: this slip of land, therefore, belongs, as I have said, to the continental soil.

Oct. 10*th*. I set out from *Poole* at about seven in the morning, and first crossed the ridge of the hills which separate this vale from that of *Christchurch*. When I was at a sufficient height on these hills to have a view of the whole gulph of *Poole*, the tide being out, it appeared to me like an immense marsh. On the west, I saw *Wareham*, already become an inland town by the formation of meadows before it; though formerly its commerce was no less extensive than that of *Poole*.

594. As I travelled along this road, I saw the high hills still covered with that heath which is taken off for fuel; but cultivation was beginning to spread over the slopes descending towards the vale of *Christchurch*. Before I reached that town, I crossed several small hills covered with sand and gravel, under which are strata of white clay; among these hills, however, there is still one of *chalk*.

595. The town of *Christchurch* stands near the sea, on an eminence which it is visible was formerly an island, and which divides the courses of two rivers, united with each other a little below, the *Stour* already mentioned, and the *Avon* arriving from beyond *Salisbury*. The appearance of the place shows that these two rivers formerly discharged themselves separately into a gulph; and the ancient name of the

town corresponds with this circumstance: it takes its present name from a Gothic church which stands in it; while formerly it was called *Twinham*, from its twin rivers. But the waves and the tides have brought into this gulph such a quantity of sand, that this, with the addition of the sediments of the rivers, also retained here, has not only united the original island to the land, but has formed several low islands covered with meadows, and has even so much raised the intervals between the latter, that none but very small vessels can now come up to *Christchurch*. I learnt here, that when both the rivers overflow during the highest spring tides, these islands, as well as the meadows extending for a considerable way along the course of the streams, are still inundated: but they hereby gain additional height, new sediments being thus deposited on them. This is one of the *chronometers* found on all coasts; I have already adduced numerous examples of it, and we shall presently come to one of its criteria, resulting from the very objection which has been opposed to it.

596. A row of cliffs, consisting of argillaceous strata intermixed with sandy, extends from this place to *Lymington*, a distance of ten or eleven miles: now these cliffs will renew the proof which I gave in my former works, that our continents were produced by a single revolution, at an æra not very remote in comparison with that supposed in some histories of the earth. I have already introduced this object at the beginning of my Travels in *England*, in speaking of

the coasts of *Suffolk* and *Essex*, which led me to examine the Huttonian hypothesis of elevations of some parts of the *coasts*, very *modern* comparatively with the formation of the *continents* themselves; an hypothesis tending to involve in uncertainty the innumerable proofs supplied by the coasts, of the small antiquity of the revolution whereby the bed of the sea was changed. The circumstance which I there directly opposed to this hypothesis was that, in the above revolution, a change took place in the *nature* of the *liquid* of the sea; a circumstance not possibly assignable to any partial elevations of the coasts: and the proof which I gave of this change consisted in the *shells*, very well preserved in the soft strata near the coasts, but no longer living in the neighbouring sea, some of them, indeed, not now existing in any sea; and of this we shall here find new examples.

597. I had already observed these cliffs, many years before the journey which I am now relating, with one of my nephews, of whom I have before had occasion to speak; we then passed together some days with the late Lord Bute, at *High Cliff*, a very pleasant house about three miles from *Christchurch*, which he had built at a little distance from the edge of the cliff, for the enjoyment of the sea air in summer. The variety of the fossil shells, which we found under the cliffs where they were crumbling down, induced my nephew to return thither some years afterwards, and to visit, at the same time, the

neighbouring part of the *Isle of Wight*. With this view, he procured a work published in *London* in 1766, by GUSTAVUS BRANDER, a foreigner, who, having resided many years at *Christchurch*, had much frequented the foot of the cliffs after new falls of their materials, especially near *Hordwell*, and had thus made a large collection of *fossil shells*, principally proceeding from a stratum of bluish clay. His work is intitled *Fossilia Hantoniensia*, (*Hampshire* fossils;) plates of them are annexed, their nomenclatures and descriptions being furnished by Dr. SOLANDER, and they consist of eighteen genera, and eighty four species.

598. My nephew's observations during the above excursion, and his remarks on the fossils of *Hampshire*, as well as many others which, from time to time, he has communicated to me in his letters, are extremely interesting; I hope that he may hereafter publish them at full length; and I shall therefore here extract only the most essential circumstance relative to this part of the country, before I proceed to give an account of my own observations; because his remarks will serve as a proper introduction to mine with regard to other phenomena.

599. The first object which it is important here to have in view is indicated by Mr. Brander in the following words: " Of these eighty four species, but " very few are known to be natives of our own, or, " indeed, of any of the European shores; but the

" far greater part of them, upon a comparison with " the recent, are wholly unknown to us." Now with respect to *time*, it will be seen more and more in the sequel, from the operations of the sea upon the coast of *Hampshire*, that this coast cannot have existed during a very great number of ages. To this then, as well as to those of *Suffolk* and *Lincolnshire*, Mr. Playfair should apply the Huttonian hypothesis of *partial elevations* of the coasts, *very modern* in comparison with the production of the *continents* themselves. But how could the *elevation* of this *coast* have so essentially affected the nature of marine animals, not only in the European seas, but in every part of the ocean? Such an effect cannot be ascribed to it with any probability; and besides, my nephew's observations will show this coast to be so far from having experienced any *elevation*, that the *Isle of Wight* has been separated from it by a *subsidence*.

600. My nephew landed on that island in a cove called *Alum bay*, near the *Needles*, at its western extremity; it being there terminated by a promontory rising abruptly, composed of *chalky strata*: he gave me the following description of that part of it in one of his letters. " The two sides of this hill, which is " at least six hundred feet high, are cut down verti- " cally. It is composed of *strata* of *chalk*, descend- " ing towards *Alum bay* with an angle of seventy or " eighty degrees. Of the *Needles*, there are three " principal ones, terminating the cape; and the plane

" of their *strata*, turned towards the coast of *Hamp-* " *shire*, is so evidently the continuation of the side " of the hill above *Alum bay*, that they seem to have " been placed along a stretched line extending from " it. This small bay is formed by a cape projecting " on the east, and presenting in its side turned to- " wards the west, the section of *strata* very different " from the chalky, against which they rest; for these " are of *clay*, their species however changing, from " stratum to stratum, beginning from those of *chalk*; " at first, they have the same inclination with the " latter; but they become more vertical as they ap- " proach the arm of the sea, in which it is evident " that they have dipped in their subsidence. If any " proof be required that these *argillaceous strata*, now " nearly *vertical*, have been formed, as well as those " of *chalk*, in an *horizontal* situation, (the former on " the latter,) this proof is supplied, not only by the " marine bodies contained in them, but by one of " the *strata* themselves, which is from five to seven " inches in thickness, and consists of rounded *silices*, " strongly cemented together with a ferruginous " gluten; it not being possible that this stratum of " *gravel* can have been formed otherwise than in an " *horizontal* position.

" During the short time that I remained in *Alum* " *bay*, I found in its *argillaceous* strata eight of the " species of shells described in Brander's work; " namely, *Buccinum desertum*, *Helix mutabilis*, " *Murex pyrus*, *Strombus luctator*, *Turbo vagus*,

" *Turbo terebra*, *Venus rotundata*, and *Cardium* " *edule*, the three last of which only are found on the " coasts of *England*. These are circumstances very " characteristic of identity, between the almost *ver-* " *tical* strata of *Alum bay*, and those nearly *horizon-* " *tal* of the opposite coast of *Hampshire*; and if, " instead of the few hours which I had to spend in " observing the former, they could be visited every " year after the season when they crumble down, as " those of that opposite coast were by Mr. Brander, " I am persuaded that this identity would become " more and more evident, from the additional num- " ber of fossil shells that would be found similar on " both sides. Now as it cannot be doubted that the " *argillaceous strata* of *Alum bay* were once horizon- " tally situated on those of *chalk*, against which they " are now seen to rest, is it not reasonable to con- " clude, that the *argillaceous strata* of the neigh- " bouring coast were originally at a higher level, also " covering those of *chalk*; and that, when the *Isle* " *of Wight* was formed by a great subsidence between " it and the coast now opposite to it, the subsidence " was such on the latter side, that the *chalky strata* " there disappeared below the actual level of the sea; " while in the *island*, the *strata* sinking less on " the southern side than on the northern, they were " all strongly inclined towards the intermediate " space?

" A phenomenon which I have observed on the " coast of *Sussex*, nearly eighty miles to the east of "this, confirms the above conclusion, by shewing "still more evidently the astonishing disorder pro- "duced by these catastrophes among the different "classes of strata. It is near *Newhaven*, on the "western side of the mouth of the river *Ouse*, that "there is, on the summit of a *chalk* hill nearly insu- "lated, a mass of *argillaceous strata* containing a "great abundance of fragments of a bivalve, appear- "ing to me to be the *Cardium edule*; and in the "upper stratum there are quantities of the common "oyster, *Ostreum edule*; a circumstance which con- "nects these *strata* with those of *Hampshire*; but "the *argillaceous strata* have been carried away "from the top of the *chalky*, either entirely or in "part, according to their situations; on the hill near "*Newhaven*, the former have much less thickness "than in *Hampshire*; and farther eastward, between "*Seaford* and *Beachy head*, they are altogether "missing, the grass growing immediately on the "*chalk*.

"Moreover, all these *argillaceous strata* formed "on those of *chalk* indicate, that, after the formation "of the latter, a great change took place in the liquid "of the sea, by which *marine animals* were much "affected; for, in the *strata* of *clay* now lying or "having formerly lain *on* the *chalk*, we no longer "find the *gryphites*, the *cornua Ammonis*, the *belem-* "*nites*, and some particular species of *ostrea*; "though these marine bodies abound in other *argil-*

"*laceous strata*, found *under* those of *chalk* in coun"tries where they are associated with them."

601. These are exact observations, as it is desirable all those should be, whence any geological conclusions are to be drawn: I shall now resume the account of my own, in the course of the journey which I have already begun to relate; and in those connected with the *Isle of Wight* will be seen a confirmation of my nephew's conclusions, with respect to the nature of the catastrophes undergone by our mineral strata.

Oct. 11*th.* I employed the morning in observing the neighbourhood of *Lymington*, where the *haven*, like most of the openings of the coast so called, is the extremity of a vale, between two ridges of hills coming down to the sea. We find here again the *mouth* of a *stream of water*; but this *stream* is very small, when compared with the *opening by which it makes its way to the sea.* The opposite hills descend towards this vale with a gentle declivity, the town being placed on the slope on the western side. The tendency to filling up is observable here, as it is, more or less, in all *havens*, and a great cause particularly contributes to it both here and at *Christchurch*; namely, the extent of the argillaceous cliffs lying between these two places; as the materials falling thence, being alternately carried to the opposite sides by the currents and the waves, are deposited in the havens, where the sea-sand always follows and retains them.

602. At *Lymington*, not only the whole haven has been filled up, but, as is the case at *Christchurch* also, large islands have been formed along the coast. There is a *dam* across the ancient gulph from one side to the other; this serves as a bridge, the little river passing through an opening in it, when not opposed by the tides entering through the same opening: but as the latter have not time to extend themselves very far before they retire, the interior space is almost become a lake of fresh water. I went on the bridge, and though the tide was already much risen, I saw this space nearly filled up with mud, even with the surface of the water, and in many places covered with grass: its progress indeed is such, that there were men at work in making a sluice in the dam, for the purpose of letting the water run off from within during the ebb, and preventing the return of the tides. By means of this, a very large space will be changed into good meadows, no longer subject to inundation but from the land-waters.

603. Below the dam, and along the town, there is a quay, to which small vessels still come up; but they are obliged to take a circuitous course among the new lands added on both sides of the coast, the waves having at last bordered these lands with a beach towards the sea; many parts of them are already enclosed with *walls*, and are become meadows; and the intervals still open between these will undoubtedly be also enclosed in succession, for they are covered with grass, and remain dry, except during

the highest spring-tides, which form on them fresh deposites. In one of these enclosed parts, on the *Lymington* side, salt-pans have been made, into which, in the month of May, the sea-water is introduced, and kept stagnant in a wide but shallow space. If the summer is favourable, the salt is sufficiently concentrated in the month of August, to have the evaporation completed by fire. Between that time and October, a great deal of bay-salt is made in this manner; and in winter, from the residuum of the water kept in a reservoir, Glauber's salts are produced by the usual process.

604. There are in this part of the coast two different phenomena, a comparison between which may serve to distinguish the *beaches* formed by gravel driven on *sand-banks*, from those where it has been accumulated on original *bars* produced by masses of *strata* that have subsided nearly to the level of the sea. In the channel between the coast of *Lymington* and the *Isle of Wight*, but nearest to the latter, there is a space on which the sea forms breakers at high water. This space is called the *Shingles*, a name given to the pebbles of *beaches*; for at low water, a beach appears here. This kind of island has been fatal to many ships; because, as it is only on a *sand-bank* that the gravel has been here thrown up by the waves, its position shifts, and when the sea is rough at high water, there cannot be any certainty of avoiding it. But on the westward of *Lymington*, there is a submarine *bar*, extending from the coast

three miles in the sea, with a curve to the east; and on this, because of its permanence, has been produced, on a small scale, another phenomenon like the *Chesil bank:* the waves, throwing up the gravel alternately on both sides, have raised it above their own reach at the highest tides, to the breadth of about a quarter of a mile; its base being so solid, that *Hurst castle* is built at its extremity. This slip of land, terminating the strand which borders the long cliffs from *Christchurch* hither, has been the cause of the great extension of new ground on the east; the sediments having been accumulated in that part of the channel lying between the coast and the *Isle of Wight*, on account of a greater degree of calm produced there by this projection.

605. A hoy passes between *Lymington* and the port of *Yarmouth* in the *Isle of Wight;* it sails from the former place when the tide, beginning to ebb, can assist it in going out: I embarked at two o'clock. Much time was taken up in steering among the new lands on the *Lymington* side. The tide being high, the water here and there occupied large spaces; but the vessels are always obliged to follow the same narrow course, or they would run aground: as the tide became lower, the mud appeared, covered with marine plants. When we were out of this winding channel, the wind being favourable, we soon crossed the arm of the sea, and arrived at *Yarmouth* at three o'clock. In approaching the *island*, I found its aspect correspond with what I have already said

with respect to the *revolution* which formed the *present bed* of the sea; namely, that marks of this revolution are visibly impressed on most of the lands on its borders. But before I shew these effects in this island, as I have already given so many examples of the phenomenon of the *gravel* found on the coasts, and its connexion with that on the highest parts of the neighbouring grounds, I think it proper to stop, in order to consider this object under a general point of view; because its *generalization* here, when preceded by so many *details*, will serve as an explanation of all the similar phenomena which will follow in the course of these travels.

606. It is a part of the Huttonian system, as well as of many other theories of the earth, that the extraneous masses which compose the *breccias* and *pudding-stones*, whether in mountains, or in hills and plains, are fragments of anterior continents, transported along the bed of the ancient sea; and a proof of this is deduced from the *gravel* now found on our coasts, supposed, in those theories, to consist of fragments detached from our present continents, and propelled by the motion of the water along the shelving bottom of the ocean. This hypothesis spreads a thick veil over all the operations which took place on the bottom of the ancient sea, as well as on those which are now passing on our continents and along their coasts. I have shewn its fallacy in my former works; and I shall now present here, in one point of

view, the facts already detailed in these travels, whereby it is formally opposed.

607. The accumulations of *gravel* bordering so many coasts, which I have called *beaches*, certainly do not proceed from the *rivers* arriving there; for rivers bring nothing to the sea but the earthy particles composing the extensions of the coast near their mouths. *Gravel*, indeed, is seen on the beds of most *rivers* in inland parts; but it does not travel with their waters, being the same which they originally found in the soils wherein they formed their channels. A proof of this fact is evident in *alluvial soils*, composed of the sediments deposited by rivers, in parts, where they have had space to spread themselves, and have consequently slackened their course. In these soils, the *gravel* is always at the bottom, and is covered with a greater or less thickness of sand and earthy particles; of which I have already given and shall continue to give examples in these travels. The *gravel* cannot move under these earthy accumulations, in the *alluvial soils* which are always to be seen on some part of the course of every *river*, from its origin to its mouth; it is therefore very evident that the *gravel* found on the coasts cannot have been brought by rivers from the interior parts of the continents.

608. We must now examine what share the *sea*, by its operations against the coasts, may have in the production of *gravel*; and especially whether it car-

ries this gravel down to the lowest depths, as is supposed in the theories which I have here in view. Undoubtedly *gravel* is formed on some coasts, namely, such as are bordered with stony cliffs: as soon as the fragments that fall from these are sufficiently accumulated in the water to rise up nearly to its surface, the waves toss them about, grind them against each other, and thus wear off their angles; but the result of this is, as has been shewn by several examples in these travels, that the waves constantly repel towards the coast the gravel thus produced, and raise it against the foot of the cliffs, without permitting any of it to reach the depths of the ocean. This, I say, is what happens under stony cliffs; but the *beaches*, on most parts of the coasts of *England* which I have already described, have evidently a very different origin. It has been seen above, that the *gravel* composing these *beaches* is always analogous to that found on the neighbouring lands; and I have demonstrated that the latter is not carried by rivers to the sea: with respect to the gravel which falls from the upper part of cliffs composed of soft strata, its quantity is as nothing in comparison with such *beaches* as the *Chesil bank*, that passing before the two ancient gulphs at *Weymouth*, that near *Lymington* at the extremity of which *Hurst castle* stands, the *Shingles* between the *Isle of Wight* and the coast, and even the beaches on the coast of *Suffolk;* to which I may add those described in the preceding volume on the shores of the *Baltic.*

609. I have

609. I have proved that this gravel cannot have proceeded from the continents; it must therefore have been brought up from the bottom of the sea, and impelled against the coasts; consequently it does not move towards the depths of the ocean. Most *beaches* have a *maximum* of increase, because the *gravel* cannot be impelled on them from any depth of water greater than that which is put in motion by the winds; and after the gravel is exhausted, the waves bring up with them nothing but sand: in places, however, where the sea is shallow to a great distance, and its bottom is entirely covered with gravel, as I have shewn by examples on the shores of the *Baltic*, the action of the waves, still employed in raising and widening the beaches, has not yet brought up on the coast all the gravel within their reach. These facts, when combined, leave no other assignable cause of the *gravel* in question, but that to which, in §. 505, I have ascribed the enormous quantity of it composing the *Chesil bank;* namely, the formation of the present bed of the sea by the *subsidence* of ancient lands which, in these parts, were covered with *gravel*. I have made it appear that the characters of this revolution are visibly impressed on most of the coasts which I have hitherto described; and I will now shew the correspondence, in this respect, between the coast of *Hampshire* and the *Isle of Wight*, as I have already shewn that between *Portland island*, and the neighbouring coast.

610. As soon as I had disembarked at *Yarmouth*, I set out on foot to follow a ridge of hills proceeding from the interior part of the island, between two other similar ridges, and separating two long *æstuaries; Yarmouth* being situated at the entrance of these, where they are united. The *æstuary* on the eastern side has been almost entirely filled up by the waves and the tides: I walked along the hill beside it, as far as its head, and I saw that it was crossed by three dams; there was no water but between the first and the second of these, reckoning from the sea; the two other spaces were already covered with meadows. From the height which I had reached, I perceived the other *æstuary* extending beyond my view into the island; the ridge of hills bordering it on the west, like that on which I was walking, consists of *argillaceous strata* in the parts terminating at the coast. I saw also, towards the south, much higher hills, spreading their branches on all sides, and dissecting the island into various *combes*. Lastly, after having passed beyond the first æstuary, I came to a part of the hill, where I observed thin strata of *lime-stone* used in the stone fences enclosing the fields. This first prospect interested me, and I determined to visit the whole island.

Oct. 12*th*. I set out from *Yarmouth* at eight in the morning, in an one-horse chaise with a guide. I first followed the western æstuary, which, in this narrow part, cuts the island almost across: its length is reckoned to be about seven miles, on account of its windings. This is in fact a *combe*, of which the level happened to be lower than that of the sea, when the latter changed its bed; visible marks of this revolution being impressed on every part of the island. I have already said that the southern part is the highest; and there all the eminences, irregularly arranged and full of intersections, consist of *chalky strata*, so much shattered, that the surface is composed entirely of rubbish. From these ridges, or rather *heaps* of *chalk*, the island becomes lower towards the northern part, shewing, as will be seen, all the signs of a confused subsidence of the different kinds of strata towards the point of its separation from the *Hampshire* coast.

611. In the direction of the *æstuary* from north to south is seen, near its termination, on the latter side, a large opening in the ridge of the high *chalk* hills; as this is in the parish of *Freshwater*, it is called *Freshwater gate*, and gives that name to a hamlet on the coast; a small bay near it being also called *Freshwater bay*. As I ascended the æstuary, passing over the eastern hills, I came to a point where the *lime-stone* strata appear at the surface, as they do in many other parts of the island; and there I saw several quarries. Across this æstuary, at some distance from its extremity, there is a dam with a sluice, which is opened when the tide ascends, that it may fill the space thus separated from the rest; after this, the sluice is closed, and continues shut till the tide has retired, when it is again opened to-

wards the bottom, in order to let the enclosed water pass out under the wheel of a mill, till the return of the tide. Mills of this kind are called *tide-mills:* I shall mention some at the extremity of other æstuaries, without again describing their construction. The waters of part of the neighbouring hills enter this enclosed space, and run off with the tides, of which, at low water they follow the channel: the small stream formed by them is called the *Yar*, and gives the name of *Yarmouth* to the little town which is near its discharge into the sea in the northern part of the island.

612. Having crossed a small ridge of hills at the extremity of the *æstuary*, I entered a wide and beautiful *vale*, following the inner foot of the *chalky* hills, in a direction parallel to the coast, which is at no great distance. How could a large *vale*, in this position, have been *excavated* by *running waters*, when it is impossible that any *stream* should have been formed there? Beyond this vale, I came to the point whence the *chalk* hills rise on both sides of *Freshwater gate;* those on the west extend themselves in a long promontory terminated by the *Needles;* but to the breadth of this promontory are added other species of strata, lower than the chalk; and these, by their projection to the northward, form on the western side *Alum bay*, above described by my nephew. I ascended this promontory, which is nearly three miles in length; the *chalk* is here partly covered with sand, and there is only a thin down on the surface.

The *vale* already mentioned rises, till it terminates with little depth between the highest part of the *chalky* promontory, and the lower strata of a different nature, which are cut down abruptly towards *Alum bay* on the west, and *Totland bay* on the east. In this prolongation of the vale, here rising and separating the two species of *strata*, the grass is so thick, that the transition from one to the other cannot be observed; but its *section* appearing on the side next *Alum bay*, it is there seen that, among the nearly vertical *strata*, those in contact with the *chalk* are of *pipe-clay*, and that those which follow, pass through different shades, till they become brown. I did not descend into this *bay*, as it would have taken up too much time, and was besides unnecessary, since my nephew had described it; however I learnt afterwards two interesting circumstances respecting the above strata; the first is, that one of them is *aluminous*; and that, having been worked for some time to make *alum*, the bay has thence derived its present name; the other, that, among these nearly vertical *argillaceous* strata, there is one of a *sand* so pure, that it is carried as far as *Bristol* to be used in glass-houses; it is worked chiefly on the side next *Totland bay*, where its section also appears.

613. There is a very high light-house at the extremity of this promontory; I ascended thither, and had from it a fine view of all the western coast, as far as *Portland island;* but in this spot my interest was chiefly engaged by a family in which I was re-
ceived

ceived with the greatest hospitality; the good-humoured and amiable characters of all the individuals who composed it appearing to render their situation very agreeable to them, though nearly as much sequestered as it could have been in a desart island. This family consisted of a husband and wife, and several children; they were comfortably lodged in the lower part of the light-house; and their kindness, not confined to each other, was extended to all the living creatures around them in any degree capable of being domesticated. Besides a brood of Bantam fowls, which flew up on their knees, I saw some rabbits, which I took at first for tame ones; but I found that a colony of wild rabbits, from a large warren on the hill above *Alum bay*, had come to settle on this promontory; and that as those belonging to the burrows near the light-house were never molested by its inhabitants, but were occasionally fed by them with cabbage and lettuce leaves, they frequented the house with the utmost familiarity, freely entering and going out; being pleased with the caresses of the children, and often jumping into their laps. When I expressed my pleasure at seeing so much hospitality extended to animals, they desired me to raise my eyes to the cieling, where I saw an owl at roost on a wooden frame purposely suspended for him by strings: he did not discompose himself, when I went under it to look at him; but only cast his eyes downwards, to consider me in return. This owl was perfectly at liberty; and they told me that, when it grew dark, he flew towards the window, expecting them to open it, if the door was shut; that he spent the night abroad, preying on the mice, which then came likewise out from their holes in the down; and that in the morning he watched till the door was opened, when he brought in with him some of the mice that he had caught, in order to finish his repast on his frame, remaining there till the following night: when the ground was covered with snow, they gave him occasionally pieces of meat. In the summer, the children went to school at a village two miles from this spot; but when the season became too severe for them to walk there, the father and mother, and an elder sister, continued their education.

614. Besides the cordial hospitality with which this family treated me, the father accompanied me round the promontory, as well on the side next *Alum bay*, as on that opposite to it, abruptly cut down in the same manner; and it was from him that I learnt the circumstances relating to the two above mentioned *strata* on the former side. We then went on to the *Needles*, to my nephew's account of which I shall add only a few circumstances. These pyramids are destroyed in succession by the weather: their *strata* being nearly vertical, the surface is shivered by the frosts into laminæ, afterwards detached and carried away by the winds; on the neighbouring ridge, the soil of the down is entirely composed of the fragments of these laminæ, and has been gradually elevated by them, within a certain distance, in a very perceptible degree. But this promontory being very

narrow, the winds, widening the fissures which intersect it, form from it new needles, by shaping into pyramids the parts thus separated from each other, when they have opened for themselves a free circulation around them.

615. Besides the *flinty strata* interposed between those of *chalk*, which dip so rapidly, the *chalk* itself contains a great quantity of small *silices* scattered through its mass; these are in general of an oval form, from the size of hen's eggs, to that of small *beans*; thus resembling those which are desseminated over the hills on the borders of the *Chesil bank*, and compose that bank itself. In my former works, I have explained my reasons for considering these *silices*, scattered over the surface of so many soils, as proceeding from the decomposition, on the bed of the ancient sea, of the *chalky* strata wherein they were contained. None of the causes, acting on the continents since they have existed, can account for the dissemination of the *silices* on hills, of which the mass consists of *strata* of a very different kind; and to this consideration I shall more particularly return on a future occasion. Here, however, there are *chalky* hills; and these may assist the imagination in representing to itself a transportation of some kind; but in the vast extent of countries described in the first volume of these Travels, which are every where scattered with *siliceous* fragments, there is not the smallest appearance of *chalk*; besides, among the latter *silices*, there are some of colours which I never saw among those

belonging to our *chalk*: and on the banks of the *Rhine* and the *Moselle*, there are, among gravels of various species, *agates*, *onyxes*, and *calcedonies*, still covered with their *crusts*; and these are all, no less visibly than our common *flints*, stones formed in *calcareous strata* of a kind no where found at present. I shall return to this subject on a future occasion.

616. I quitted the light-house early in the afternoon, and first proceeded towards the opening of which I have spoken, on the southern side, named *Freshwater gate*. In my way back over this high promontory, the island towards the east had the appearance of a plain, slightly undulated, and very fertile, with several ridges of hills passing across it; but, as I descended the slope towards *Freshwater gate*, I saw this apparent plain dissected into small hills; and the nearest of the large hills, which are of *chalk*, soon intercepted my view of the eastern side of the island. When I had reached the lowest point of this intersection of the large hills, I went down to the hamlet of *Freshwater gate*, consisting only of a few fishermen's houses. The hill on the eastern side of this passage rises gradually, covered with downs; that on the western side is cut down abruptly in the upper part, and discovers a section of *chalky strata*; but they are broken, and in such confusion, that it is impossible to judge of their real direction. The slope under this section shews, at the top, only fragments of chalk; but below, it is covered with argillaceous sand. *Freshwater bay*, which extends towards

the east, begins with an abrupt cape, called *Afton cliff*. There is here a strand composed of sand, and a beach of *flints*, proceeding probably from the chalk of the hills. The quantity and size of these flints increase near the cape, where there is so great an abundance of them, that they are fetched for gravelling the roads in the neighbourhood. From hence I saw in the sea, in several places along the coast, masses of *chalk*, not so high as the *Needles*, but resembling them in form; and as thus it is probable that their strata are much inclined, they point out a subsidence of the *chalky strata* on this side below the level of the sea.

617. The abrupt cape of which I am speaking is called *Afton cliff*, from a hill named *Afton down*; and this leads me to give a general idea of the nature of the island. It is in the form of a lozenge, its greatest length, from east to west, being about twenty two miles in a strait line. Its surface is intersected by eminences of chalk, covered with downs. All these eminences, separated by spaces varying in breadth, have distinct names, perfixed to the general appellation of *down*; excepting the narrow promontory, which terminates with the *Needles*, and which, being cut off abruptly towards the sea, is called *Freshwater cliff*, the strand below it having the name of *Main beach*. Beyond *Freshwater gate*, the island continues to increase in breadth to nearly the middle of its length, where it measures about thirteen miles across in a strait line.

618. Beyond the opening in the hills at *Freshwater*, the same ridge of *chalk*, which forms the promontory, continues to prevail along the southern part, at a greater or less distance from the coast, nearly to the middle of the length of the island; and its distinct eminences, reckoning from the west, are *Afton down*, *Tapnell down*, *Shalcomb down*, *Brixton down* and *Chillerton down*; the latter beginning to turn northward towards the interior part of the island. From the inner side of *Brixton down*, branch off *Gallibury down*, *Buccomb down*, and *Ape's down*, extending northward to the middle of the breadth of the island, on the west of *Newport*; and *Gatcomb down*, *St. George's down*, and some smaller eminences, stretch away, but more irregularly, from *Chillerton down*, towards the east of the same town. I shall have occasion to describe this eastern part, which is very irregularly intersected by hills of various kinds; and this will lead me to a general remark on the formation of the island, and its correspondence with the country whence it is separated by the sea.

619. Returning from the strand near *Freshwater gate*, I went towards *Newport*, the principal town in the *Isle of Wight*, situated at the head of an æstuary, which opens on the north at *Cowes harbour*, and thence penetrates to the centre of the island. In my way, I followed, on the northern side, the bases of *Afton down*, *Tapnell down*, and *Shalcomb down*; then, turning northwards, I proceeded along those of *Gallibury down* and *Buccomb down*. This whole

road lies over low hills, along the foot of the eminences of *chalk*; the surface of the former, down to a certain depth, is composed of argillaceous and sandy strata, covered with a quantity of siliceous gravel; but under these strata is *lime-stone*, which, in some places, shews itself near the surface: I saw, in my way, some houses that were built of it; and higher up, I observed the quarries whence it was taken; they were at the foot of a *chalky* eminence: but all the surface of the low hills being either covered with grass, or in tillage, I could not discern the points of junction of the different *strata*. Among these hills advance some branches of the eminences of *chalk*, having their extremities abruptly cut off towards the low grounds: as I descended towards *Newport*, I passed under several of these branches, presenting great sections of *chalk*; but I could not distinguish the *strata*, nothing appearing there but rubbish.

620. Having arrived at *Newport* at five o'clock, I employed the rest of the day in walking about the town, which is very neat, and in visiting its environs. This is a sea-port, though nearly in the centre of the island; because a *vale*, five miles in length, having happened, at the birth of the island, to be below the level of the sea, became an *æstuary*, which opens at *Cowes harbour*, and extends itself inland as far as *Newport*; but it is very much filled up, like all similar arms of the sea, so that only small vessels can come up to the quay at the bottom of the town;

these ascend with the tide, and remain aground when it retires. A canal surrounds the town, into which, opposite to the port, fall two small streams, called the *East* and *West Medina*, from the names of two sides of the island, whence they arrive, and where they are formed by the springs issuing from the sides of the combes. Both these streams, in their respective channels, have their level kept up by several dams, for the purpose of producing falls for mills; below the town they unite together, and continuing their course at low water in a single channel, along a great part of the æstuary, that part is called the *River*. I ascended the hills on the east, with the intention of obtaining a view of the upper part of the æstuary; but I could not see the bottom of the vale, which, being narrow and winding, was concealed by the slope, as far as my sight extended.

Oct. 13. I set out from *Newport* at half past nine in the morning, and went towards *Niton*, a village at the distance of about nine miles, situated on the southern coast, near the point where the island is of the greatest breadth. I first ascended between two eminences of *chalk*, separated by a fine vale; after which, those eminences retiring on both sides, I came into a country, where, from the rural aspect of the low hills, extending to a considerable distance, I could have forgotten that the sea was so near. The road, in passing over some of these hills, is cut down to a great depth; and in the lower part of these sections appear very regular *strata* of a reddish argillaceous sand: some of this sand having been washed by my nephew, he found that its colour proceeded from the clay mixed with it; the sand itself consisting of transparent and colourless grains. On these *strata*, there are accumulations of *siliceous gravel* mixed with sand; their thickness is irregular, being from one foot to five: in some places, this *gravel* forms the surface; but in others, the *sand* covers it to a great depth. These different *strata* follow very regularly the slopes of the surface; but in some parts, they present their section on the sides of the *combes*.

621. The soil of these hills rises gradually towards the coast; and the highest ridge of them, of which the surface, much intersected, is covered with the same siliceous gravel, produces nothing but heath and furze. On the opposite side, they descend towards *St. Catherine's Tower*, and *Niton* whither I was going: here, the country is again cultivated; and I saw the houses built of a very hard *sand-stone*, which makes no effervescence with aqua fortis, and of which the parts freshly broken show a shining grain. The *strata* of this particular class form a great feature on the coast of the southern part of the island, and the road is in some places cut through their mass: on the side of a *combe* descending towards *Niton*, where a section of them appears, they are in a very great disorder, resulting from their numerous fractures.

622. On arriving at *Niton*, which is near the sea, I saw on both sides a great breadth of coast, formed of the ruins produced by the catastrophe whence resulted the present bed of the ocean; for no cause now existing on the continents can have occasioned so vast a chaos. On the eastern side, at a great distance from the sea, there appears above these grounds a large abrupt section of the *sand-stone* strata; under which the slope descending towards the sea is composed of great masses of these *strata* heaped on each other, and buried, more or less deeply, under other materials, which are covered with grass. I approached the foot of this abrupt side, and found its aspect very picturesque, on account of its many ruptures and projections, and because, as the stone is unequally eroded by the air, its surface appears to be carved into a kind of coarse filagree. The *chalky* eminences rise above this section of the *strata* of *sand-stone*, which, in this part of the country, seem to form the basis of the *chalk*. Near *Niton*, these eminences do not come to the edge of the above section, there being at their foot a certain space nearly horizontal, where a soil, composed of their rubbish with that of the sand-stone, is brought into tillage; but the eminences of *chalk* gradually approaching the edge, a slope consisting of this rubbish is at last formed from their summit down to the soil composed of the large fragments, and by this slope the section of the *sand-stone* strata is entirely concealed.

623. In one part of my way eastward, I saw the surface of the space beneath the rocks, over which the road passes, so entirely covered with large masses of these rocks, that it is left to its own spontaneous products, the grass, with a few bushes, every where overspreading them. Farther on, smaller fragments having filled up the intervals of these masses, or rather, perhaps, not having been washed thence by the waters, the surface is capable of being cultivated; and in this zone, which is of considerable breadth, stands the village of *St. Lawrence*. The same soil continues to the point where the eminences of *chalk* at last extend their slopes over the edge of the strata of *sand-stone*, and cover it with their own fragments, down to the level of the cultivated lands; and from the rapid declivities of these slopes, on which there is only a thin down, this spot is called *Steep hill*.

624. The following eminence of chalk has the name of *Boniface down*: the low soil of the coast here rises gradually along its foot; and on a promontory formed by the latter, my worthy friend Mr. Thomas Bowdler had a country house; it was long since we had met, and I rejoiced in an opportunity of seeing him again. I arrived at his house at about two o'clock, but he had been absent for some days; however I learnt that he was expected at home in the evening, and was not to bring any company with him; wherefore I determined to stay there that

day, and I employed my time, till his return, in observing the neighbouring ground.

625. The house is situated very near the *chalk* hill, of which the declivity, is so rapid, that the sheep cannot graze on it in any other manner than by forming for themselves transverse tracks, at such a distance, that these animals, by the motion of their heads, can reach all the grass in the intervals between them. There are even many places, where it has not yet been possible for the turf permanently to fix itself; because, the whole slope being composed of rubbish only, the great rains cause parts of it to slip down, with the grass which is on them; and when the surface is thus stripped of its covering, it is a long time before such herbage as gradually overspreads it can reproduce on it the vegetable earth necessary for the growth of new grass; so that, on all these slopes, white patches here and there appear. I shall speak hereafter of all that art has done for the improvement of this place, confining myself for the present to the natural terrace, on account of which this spot has been chosen for the situation of a country house.

626. This terrace stretches forward across the loose soil in a promontory, terminating, after a deep inflection, in a small mount, where Mr. Bowdler has built a summer-house, which commands the sea, and whence there is a full view of this extraordinary coast. The lateral slopes of this extremity of the promontory are

very rapid, and planted with shrubs; those of the broader part, less steep than the former, are covered with turf: I descended the eastern side, the very unequal surface of which, though grassy, shows it to be composed only of large masses fallen from above. I went down by this way to the sea-shore, near the village of *Bonchurch*; and I found there a strand of considerable breadth, extending both to the east and to the west under the cliffs, which are very different in their nature on these two sides, those on the west belonging to the promontory, and those on the east being the immediate foot of the high hills: I first proceeded along the latter side, on a beach composed of siliceous gravel; and I found the cliffs, which are about one hundred feet in height, to be a section of the strata of *sand-stone*; for, in this part of the coast, the eminences of *chalk* retiring by degrees, as they do on the *Niton* side, leave at their foot a wide terrace composed of the *sand-stone* strata. It appears that the fragments of this stone falling on the beach are decomposed by the sea-water; so that, when the tide is in, the waves still beat against the foot of the cliffs, which continue to crumble down; but there are parts where, the beach being broader and higher, the degradation has ceased, and the cliff is reduced into a slope covered with grass; I followed it to the point called *Dunnose*, where *Sandown bay* begins, which turns to the N. N. E., and at the other extremity of which I saw *Sandown Fort*, standing on a cape of *chalk*.

627. Having returned to *Bonchurch*, I thence proceeded westward on the strand continued under the abrupt extremity of the promontory which advances in the front of *Boniface down*. After passing the section of the grassy slope, I followed cliffs less high than those on the eastern side, and presenting at first the section of the *strata* of a soft *sand-stone*, seen to descend rapidly behind, under a thick covering of loose soil. Afterwards I came to the bottom of a combe, which rises towards a *chalky* cliff, as high as those of *sand-stone* on the east; and here the nature of the promontory changes, its section showing masses of *chalk* without order; the soft fragments of these, mixed with the siliceous gravel on the strand, rendered it extremely fatiguing to walk there. When I had passed the promontory, beyond which the ground descends in a grassy slope to the strand, I found farther westward the beginning of some lower cliffs, formed by the fallen masses of the *sand-stone* strata, detached from the section seen above the chaos of the fragments which compose the low soil from *Niton* to *Steep-hill*.

628. Returning hence towards *Boniface down*, I ascended the grassy slope which separates these two kinds of cliffs, and found on it, partly buried in the soil, a number of large projecting masses, belonging to the *strata* of the hard *sand-stone*. Here a greater subsidence of the *strata* has taken place, attended with greater disorder; so that no masses have re-

mained of sufficient height and continuity to form *cliffs* towards the sea.

629. By this way I went back to the house, where I had the pleasure of finding Mr. Bowdler returned: having been informed of my arrival, he received me in the most friendly manner, and I spent with him an evening equally interesting and agreeable. I communicated to him my idea respecting the phenomena of this part of the coast; namely, that its extraordinary form proceeded from the subsidence, below the bed of the sea, of the whole mass of the *strata*, as well of *sand-stone* as of *chalk*, originally extending themselves on that side; the high *sections* of these *strata*, and the heaps of their fragments which compose the low soil from *Niton* to *Steephill* and the promontory before *Boniface down*, remaining as signs of that event. This conclusion agreed with his own observations; and he obligingly offered to show me the next day some circumstances, which I could not yet have remarked, but which had been brought to view in forming the foot of the hill down to the terrace into a pleasure ground.

Oct. 14*th.* In the morning, Mr. Bowdler led me first to the foot of *Boniface down*, under which his house stands. I have said that, in this part of the coast, the *chalky* eminences advance so near to the sea, that slopes of their rubbish have covered the section of the *strata* of *sand-stone*. On the west of the promontory which I have described, a slope of this kind extends itself down to the lower soil; but in the part where the promontory projects, the rubbish having been cleared away at a certain height on the slope, the section of the *sand-stone* has been found, and has proved very favourable to the embellishment of the place. The strata in this section forming several small terraces, wherein they are much fractured, trees have been planted here, the roots insinuating themselves through the fissures; and thus a wood has been produced on the slope, which, coming down to the promontory, extends itself on both sides of the space occupied by the house, with its offices and gardens, and a fine lawn enclosed with a railing. In the wood on the rapid slope above, walks have been formed along the stony terraces, with winding paths from one to another; seats being made in some natural grottoes, and benches placed before such openings in the wood as afford fine views of the sea or of the coast. Below the chalk, and above the section of the stony strata, a spring breakes out, which has been so directed as to produce small cascades, received in basins, one below another, hollowed out in projecting parts of the rock.

630. Mr. Bowdler and I afterwards ascended, by a steep grassy slope, to that part of the eastern cliffs, where, as I have said, the *chalky* eminences begin to recede, and leave the *sand-stone* strata uncovered. These form a terrace, at first only overspread with grass; but, as it extends eastward, it increases to a

sufficient breadth to have its soil, consisting of rubbish, brought into cultivation, as is the case on the *Niton* side. The edge of this terrace, forming the top of the cliffs already described on the eastern side, shows all along the abrupt section of the sand-stone strata, under some parts of which are accumulated the materials that have crumbled down. We descended hence by an opening above *Bonchurch*, presenting lateral sections of the strata in the projecting parts, where they are seen to incline backwards, as passing under the eminences of *chalk*. Here, having appointed my chaise to meet me, I took leave of Mr. Bowdler, with a very grateful sense of all the marks of friendship which I had received from him.

631. Before I quit this part of the coast, where every thing denotes the *subsidence*, down to the bottom of the sea, of a great extent of the same *strata* that present their *sections* on this southern and highest part of the island, I shall relate an event which took place on the same coast in 1799, and which was communicated to me by my very amiable and respectable friend Mrs. Harriet Bowdler, who gave me a copy of a letter from a person at *Niton* to the owner of an estate in the neighbourhood, dated the ninth of February in that year. The following is an extract of it. "Yesterday I was desired by your tenant, Far-
" mer Hervey, to go down to *Pitlands*, to take a
" view of your cottage there, in order to communi-
" cate what follows. About Tuesday last, the whole
" of the ground, from the cliff above, was seen in
motion,

"motion, which motion was directed towards the "sea, nearly in a strait line. Hervey perceived the "house to be falling, and took out the curious antique chairs. The ground above, beginning with a "great founder from the base of the cliff, immediately under *St. Catherine's*, kept gliding down, "and at last rushed on with violence; and totally "changed the surface of all the ground to the west "of the brook that runs into the sea; so that now the "whole is convulsed and scattered about, as if it had "been done by an earthquake. Of all the rough "ground, from the cottage upwards to the cliff, "there is scarcely a foot of land but what has changed "its situation. The few trees by the cottage, at "the base of the rock, have changed their situation, "but are not destroyed. Hervey wanted, when I "was there, to go into the house to fetch out some "trifling articles, but I dissuaded him; and very "well I did, for soon after the wall to the west sunk "into the ground. At present, there are every "where chasms where a horse or a cow might sink "down and disappear."

632. This is not an accident of the nature of that described at *Lyme*, (§. 551,) consisting in the fall of a mass from a *cliff* composed of *soft strata*, to which some other *cliffs* of the same kind are still liable: it is similar to those still sometimes happening among mountains, on the slopes composed of *fragments* accumulated against the abrupt section of *stony-strata*, either at the epoch of the catastrophes which produced

duced the vallies, or by falls of materials since the birth of the continent. The soils of these slopes, having their under part infixed among the asperities of the rocks, and their surface bound by vegetation, may remain firm during many generations, and even for ever, unless they are sapped; but if some *stream*, swelled to a *torrent* by immoderate rains, happens to attack and undermine their base, or if any springs, issuing suddenly from the rocks, insinuate their waters among those loose materials, and detach them from the solid parts, the mass, being itself at the same time penetrated by the rain, thereby rendered heavier and less coherent, may suddenly slip down towards the bottom, till it is stopped by some new impediment; and it was undoubtedly this which happened at *Pitlands*.

633. Similar accidents are sometimes occasioned by *earthquakes*, as, for example, in *Calabria*; and hence great effects have been ascribed to that cause in some geological systems; but such catastrophes take place only in loose soils produced by the action of anterior causes. It is probable that before men, from the increase of population, had taken possession of such soils, become fertile through the lapse of time, accidents of both these kinds were much more frequent than they have since been; and that thus, for example, the *section* of the *sand-stone* strata, from *Niton* to *Steephill*, now exposed to sight, was formerly covered by the present low soil composed of rubbish,

bish, which may have slidden down from similar causes.

634. I set out from *Bonchurch* at eleven o'clock, and proceeded towards *Brading harbour,* situated at the eastern extremity of the island. At some distance, I ascended on the terrace formed by the *sand-stone* strata, the breadth of which increases, because the eminences of *chalk* recede, turning towards the north; in particular, they fall back suddenly from the road, at a point were there is a wide and deep cleft from the top to the bottom of their mass: when I again approached them, beyond this great chasm, I distinguished the *strata* of *chalk,* in a section above the grassy slope; but I saw only rubbish, either in this slope itself, wherever any part of it was without grass, or in that by the sea-side. As I proceeded eastward, the distance from the eminences of *chalk* continued gradually to increase, and I came to the village of *Shanklin,* situated in a combe extending down to the sea, the soil of which, though covered with grass, is evidently a chaos of ruins.

635. From hence, following *Sandown bay* at some distance, I crossed several ridges of small hills, which terminate at that bay in cliffs. These hills appear to be of the same soft *sand-stone* that is found at the end of the promontory of *Boniface down;* but I saw likewise here and there, on the borders of the road, some sections of the hard *sand-stone.* The upper part of these hills is covered, to a great depth, with

the same loose soil which I have described in the way from *Newport* to *Niton*, consisting of *strata* of yellowish argillaceous sand, with thick accumulations of flints, sometimes on the surface, sometimes at a certain depth between the sandy strata. I descended afterwards into a large vale, which terminates also at the bay near *Sandown fort*, and is crossed on a long causeway, or *dam*, with openings for the passage of the land-waters. This is evidently an ancient *æstuary* filled up; for the whole vale consists of meadows, very rich above the dam, but not so good below it; because, as I was informed, notwithstanding a dike in its front, it is sometimes inundated by the sea.

636. I then proceeded towards *Brading*, a village situated in one of the intersections of a ridge of eminences of chalk, which extends from the interior part of the island in a direction nearly eastward, beginning near *Newport*, and terminating at the sea. The first of these eminences, on the east of that town, is *St. George's down*, which I have already mentioned; after this, there is a great interval occupied by low hills of a different nature: these are succeeded by *Arreton down*, *Ashey down*, and *Brading down*; and then, after another great interval, follows *Bembridge down*, terminating at the sea in a promontory called *White cliff*, or *Culver cliff*. The latter interval is an ancient *æstuary*, near which is *Brading*; its opening to the sea being the gulph called *Brading harbour*. The waters issuing from all the

combes of the S. E. part of the island unite together to form a stream, which follows all the turns of the feet of the small hills, and finally falls into this æstuary, nearly filled up, like the gulph itself, by the sediments of these land waters, mingled with the sea-sand: the part nearest to *Brading* is converted into fine meadows, through which the stream winds in a wide channel, but with no sensible rapidity: farther on in the ancient æstuary, the grass is less rich; however, though the season was so far advanced, I saw cattle grazing there: lastly, as is the case all along the coast on this side, there are here in the sea beginnings of new lands, of great extent; the *sand-banks* being already verdant in the parts which are left uncovered at high water.

637. From *Brading* I went to *St. Helens*, at the northern entrance of the gulph; and thence, passing by the *Priory*, I proceeded to *Ride*. This road lies across small hills, extremely fertile; I saw on them, particularly, some very fine oak woods; and the same soil of argillaceous sand covered with *siliceous* gravel continues to a great depth on the tops of the hills, as well as on their declivities. *Ride* is built on the northern slope of one of these hills, and is carried down to the level of the sea; but the accumulation of the sand on this coast is so great, that, at the ebb of the spring-tides, it is seen above water to the extent of a mile: it is sea-sand, almost pure; for at that time it may be passed over on foot or in a carriage; and it is brought hither from *Spithead*

road in such quantities, that it has nearly buried all the gravel, the waves having formed but a very narrow beach along the coast. In the most favourable situations, and especially in the creeks, vegetation is spreading itself over these new soils, in proportion as they are raised above the level of the common tides, by the sediments of the spring-tides. Already no vessels can come up to *Ride* but very small ones, nor do even these ascend so high as the town; they stop at the end of some long wooden bridges, from the solid ground to the edge of the channel, which the vessels must follow in ascending with the tide; there they discharge their lading, and if this can be done in time, they go down also with the tide when it turns; if not, they remain aground in the sand till the next flood. The houses of *Ride* are built of a *lime-stone* in which I saw abundance of *chamæ*; and having inquired whence it was brought, I was told that I should see the quarries in my way to *Newport*, whither I purposed to go.

638. I set out from *Ride*, at four o'clock, for *Newport*, a distance of eight miles; and after having crossed the first hill, I found at its foot, on the border of a vale, the *lime-stone* quarries, where the *strata* are in the greatest disorder, all split and broken by their subsidence towards the space now forming the vale; the confusion of the masses fallen into it being shown by those, which, having remained the highest, now rise above the loose soil, and form rocks on its bottom, as is seen in many vallies among

high mountains. On this hill and the following, the very deep loose soil is of the same nature with that on the low hills of which I have already spoken, with the *flints* on its surface; and here also it produces very fine oaks. When I had passed over the second of these hills; I came to a vale so much deeper, that, being below the level of the sea, it has formed an æstuary, extending a considerable way into the island, with many branches: I crossed it on a dam, with an arch under which pass the tides. This *æstuary* is visibly tending to be filled up, and all the outer coast is likewise bordered with the beginnings of new lands. If a sluice were placed in the dam, to exclude the tides, all the upper part of the æstuary would soon be changed into meadows; but the return of the water entering this space is necessary for the purpose of keeping open a channel by which small vessels ascend with the tides to the bridge; for this channel would soon be filled up, if the course of the tides were to be confined. The æstuary is called *Fishborne creek*; and as *borne* is an old word signifying *brook*, this name is probably given to it on account of a brook arriving at the sea through the vale, of which the lowest part forms the æstuary.

639. The hill which follows towards *Newport* is higher than the preceeding; I suspect that it is of *chalk*, and a branch of *Arreton down*; it has not this appearance externally, as it is covered with a great deal of gravel, and its uncultivated parts are over-

grown with heath and furze; but I saw chalk spread over the parts that were in tillage, and it is not probable that this had been brought from any great distance. This hill is not so high as the downs; but it is much higher than those beyond it, which indeed, when viewed from its summit, appear to be only the undulations of a plain; but, when I had descended to their level, I found them to be small hills intersecting the country as far as *Newport*, where I arrived in the evening.

Oct. 15*th.* I set out in the same chaise from *Newport*, at nine in the morning, for *West Cowes*, at the distance of five miles, purposing to embark there for *Southampton.* In my way I followed the top of the hills on the west of the æstuary, of which I had occasionally a view; for a long space, it lies between the hills, and is very narrow; so that here, no grass appears on its borders except in the creeks. The tops of these hills are still, in many parts, covered with furze, heath, and fern; but cultivation is extending itself upon them: seeing some white substance spread over the parts which were in tillage, I inquired of the country people what it was, and they called it *white marl*; however I afterwards judged it to be only decayed *chalk*; for I found *flints* in some heaps of it which I examined on the borders of the fields.

640. The water is deep in this gulph, and large ships come up to *West Cowes*, where the houses are built on piles along the port, whence a large pier advances,

vances, serving as a quay; and at the extremity of this lie the boats which pass backward and forward between *West* and *East Cowes.* The tide being out, the *Southampton* packet had already weighed; I took a boat to go on board it, and it sailed at eleven o'clock. When we were at some distance from the coast, I saw that in this part it was low, but that some branches of hills come down to it, the extremities of which at first cut off as cliffs, have been reduced into slopes, and covered with grass, since the sea has formed a strand in their front.

641. The wind was favourable for our crossing the sea, but not sufficiently so, for our ascending the gulph of *Southampton*, which took up a great deal of time, on account of the tacks necessary to be made, between the new lands on its borders. Near its entrance, a great æstuary opens on the east, in the lower part of the vale through which arrives the river *Hamble.* On the west, there are new grounds of great breadth, extending all the way up to the head of the gulph. In front of these grounds, on the seaside, a very broad beach advances from the coast, narrowing the entrance of the gulph; and at the extremity of this stands *Calshot Castle.* The lands bordering the gulph on both sides, down to the new soils, are low, but intersected with branches of hills; these also at first were cliffs, having been broken off in the subsidence which produced the present gulph, by the change of the bed of the sea; but since the formation of the new grounds along its borders, these extremities have been reduced into slopes, now

covered with grass. We did not arrive at *Southampton* till three o'clock.

642. This town is built on a promontory of the original soil, at the confluence of two small rivers; the *Tees* on the west, which rises at a considerable distance to the north, and after passing by *Stockbridge,* enters the most remote part of the gulph; and the *Itchin* on the east, which arrives from the north-east, by *Winchester,* and discharges itself on the opposite side of the promontory. I did not see the mouth of the *Tees,* it being at too great a distance from the town; but I ascended the *æstuary* at the head of which the *Itchin* enters. This *æstuary* is also tending to be filled up; and its most remote part is already covered with meadows, separated from the rest by the dam of a *tide-mill.* The bathing-place is near the entrance of this æstuary, on a very firm sand; the river having deposited its sediments above.

643. From *Southampton* I set out for *Windsor*; but I shall terminate here my account of this journey by some remarks. I have had two motives for not fearing to be too diffuse in my description of the *Isle of Wight* and the neighbouring coast: the first is, that, by combining these details with those which I had previously given respecting *Portland island,* the naturalists, who, from seeing islands adjacent to the coasts in maps only, have supposed their separation from the land to have been produced by the

actions of the sea, may perceive that geological hypotheses ought not to be formed, without an attentive observation of the places themselves. Those who enter into this examination find every where marks of the catastrophes and subsidences of the *strata*, which produced, in the ancient bed of the sea, while still occupied by its waters, the cavities observed on the surface of the present continents, and also those on their borders, which now form *gulphs* and *æstuaries*, as well as the separation of *islands* from the coasts: the sea, instead of having produced such effects by its supposed actions, having every where tended to obliterate them, by filling up with its sand all these indentations of the coasts.

644. My other motive for these circumstantial observations concerns the history of the *chalk* and of the *siliceous gravels*. It is with a view to this object that I have described all the eminences of *chalk*, as well in my road from *Weymouth* to the coast opposite to the *Isle of Wight*, as in my tour round this island itself; specifying the different kinds of *strata* beneath those of *chalk*, the nature of the hills inferior in height to the chalky eminences, and in what manner the *siliceous gravel* is disseminated over these hills: lastly, it is with the same view that I have brought together all the phenomena which concur to prove, that the separation of the *island* from the *coast* has been the effect of revolutions in the mass of the *strata*, and not of any actions of the sea posterior to the origin of the continents.

645. By the facts of the latter class, we are led to consider this *island* as having been abandoned, subsequently to its production, to known causes, easy to be followed in their effects. Now in the first place, none of these causes can have destroyed the *chalk* over the greatest part of the island, and disengaged from it the *flints* there scattered in such profusion; for all the *chalky* eminences are covered with a *turf* formed on the *vegetable earth* produced by the decay of plants; which shews, as I have elsewhere remarked, that the surface of these eminences has suffered no erosion from the rains. The *strata* of *chalk* have indeed undergone catastrophes, as well as all the other strata; but substances are not destroyed by simple mechanical convulsions, such as fractures, subsidences, and angular motions; and yet the *chalk* which contained this immense quantity of *flints* is nowhere to be found. Besides, no cause at present in action can have scattered these *flints*, as well over the *summits* of the hills below the chalky eminences, as on their slopes, and in their vales; for Dr. Hutton's supposition with respect to the *continents*, that "there is no spot on which a *river* may "not formerly have run," cannot possibly be applied to an *island*: no river can have come from any distance to run on these summits; and if the gravel had been carried along by the rain-waters, it would all be collected in the lowest parts, and even buried there, as it is in alluvial soils, under the earthy particles, which have everywhere been the latest deposites of those waters.

646. Now what I have described in the *island* is in all respects similar to what is observed on the neighbouring *continent*, under similar circumstances; so that the conclusions are the same, and concur in confirming that, which I had drawn from facts of various kinds in my *Lettres sur l'Histoire de la Terre et de l'Homme*, and have already repeated above; namely, that the *flints* scattered over the surface of such large tracts of the continents, at present containing no *chalk*, proceed from strata of that substance which were *dissolved* on the bottom of the ancient sea, after its liquid, by the chemical *precipitation* of subsequent *strata*, had become capable, in some parts of greater or less extent, of redissolving the substances before precipitated from it. I will not repeat here the facts relating to this theory already indicated in my former works; but I shall add some which directly prove that the *siliceous gravel* existed, in its present state, on the bottom of the *ancient sea;* and these may be expressed under this general form: that, in various places, this gravel is intermixed with *marine bodies;* as in other spots, of which I have given examples in the *Elementary Treatise*, similar bodies are found amongst the gravel of *primordial stones.* A first example of this in the *siliceous* gravel is found in the *crags* of *Suffolk* and *Essex*, which have been already the object of our attention in the present volume; for the *shells* so well preserved in those strata are there mingled with *gravel* of this kind. A second example has appeared in my nephew's description of *Alum bay*,

(§ 600) where a stratum of *pudding-stone,* composed of *siliceous gravel,* is found between argillaceous strata which contain *marine bodies*; he met with another instance of this at *Shooter's-hill,* above the *Thames,* near *London;* and I also observed a similar case near *Brentford.*

647. It is then evident, that the *siliceous gravel,* now covering such extensive parts of the continent, had already been disseminated over the bottom of the *ancient sea,* and consequently was lying on the continents at their birth, when the sea retired to its present bed. I think I have been also authorized by other facts, and by chemical discussions, in my conclusion, that these *flints* belonged to *strata of chalk* dissolved in that ancient sea. I shall not repeat these remarks, when I speak again, in my next journey, of the phenomena of chalky eminences; I shall only point out the phenomena themselves, which will be found every where the same.

Journey from WEYMOUTH *to the Part of the* DORSETSHIRE *Coast called the* ISLE OF PURBECK, *and to the* GULPH OF POOLE.

August 15*th*, 1805.—I embarked at *Weymouth* in a small vessel, to go first to *Swanage,* in *Sandwich bay,* at the distance of about twenty-one miles to the eastward.

648. The wind being favourable for our keeping as near the coast as the depth of the water would permit, we first crossed *Weymouth bay*, and then came to the fisherman's cove, on the east of it, near which, in a former excursion, (§ 585) I had proceeded some way inland, in order to observe an insulated hill with a *chalky* summit. From this point eastward, the sea is bordered with very lofty cliffs of *chalk*, being the abrupt extremities of several ridges of hills, coming down from the high *chalk*-hills, and separated by *combes*, some of which form only inflexions on the top of the cliffs, and others descend down to the shore. Whoever shall attentively observe coasts of this kind, by no means uncommon, will easily perceive, that *running waters* cannot have excavated *combes*, terminating like the former of these above the level of the sea; for they receive only the immediate waters of the rain, and of a few springs; and the turf covering their sides, and growing on the *vegetable soil* which its own decays contribute to produce, proves that no erosion takes place here.

649. We proceeded towards *Lulworth cove*, where the village of *West Lulworth* appears in an excavation of the coast; and we next came before *Worthbarrow bay*, where another opening in the cliffs discloses to view a very spacious interior amphitheatre. This opening being narrow, in sailing before it at a certain distance, from west to east, the village of *East Lulworth* is first seen, situated in the eastern part of the space within; then, near the middle, ap-

pears an insulated hill, on which is *Lulworth castle*, with its park; afterwards, as this hill vanishes from sight, the western side of the amphitheatre is in its turn discovered. Only a small brook issues from the combes of this vast space, which, when attentively observed, cannot be taken for any thing but a great *subsidence*.

650. The scene soon changed, as we advanced further eastward. The hills of *chalk* receded to a greater distance from the coast, which was bordered with smaller cliffs, the sections of low hills, consisting of strata of *lime-stone*. The sea-shore also changed very much; before we reached this part, we had been obliged to keep at some distance from the coast, the sea being shallow near it; and there the cliffs had been bordered by a strand, high and broad in a greater or less degree; but when we arrived under the *lime-stone* cliffs, we found no strand, the sea being very deep; and the masses which have been detached from those cliffs, and have fallen into the water below them, not having yet risen to its level, they shew themselves only here and there at low water. Here we saw nothing but rocks cut down abruptly even below the level of the sea, except in one place, where, in the catastrophe which determined the form of the coasts at the time of the great subsidence, whereby the present bed of the sea was produced, the rupture of these *strata* of *lime-stone* having taken place farther in, a small vale was formed, between their section and a long ridge of detached masses which borders the coast.

651. Here begins what is called, I know not why, the *isle of Purbeck;* which is properly a certain hilly district, belonging to this coast: its most projecting part is a cape, called, in most maps of England, *St. Alban's head;* but in Smith's map of *Dorsetshire,* which I have used, it has the name of *St. Aldham's head,* and that of *St. Aldham's chapel* is given to a church on its summit. Beyond this cape, there are quarries, half way up the cliff, of one of the kinds of *lime-stone,* transported to different parts of the country under the title of *Purbeck stone.* Only one particular *stratum* is worked here, which lies between other strata, and is distinguished by its splitting into flags, three or four inches in thickness, used for the pavement of courts and halls, and for the side pavement of streets. It is already worked a considerable way under the superior strata, which are supported by pillars left for that purpose. All these strata have undergone catastrophes, either previously to the birth of the continents, or at that æra; for they are inclined towards *Sandwich bay;* and moreover, they are full of fractures and dislocations; so that, after some of the inferior strata have passed, in consequence of this inclination, below the level of the sea, they again appear above it at some distance; this is frequently repeated, till, at *Peverel point,* the whole mass of the strata, having passed below the level of the sea, forms there a ledge of rocks, shewn, when there are waves, by the breakers, and indicated in maps by asterisks, the usual mark to express rocks under water.

652. This is the entrance of *Sandwich bay*, the geological aspect of which is very striking. This bay opens to the east; and while its southern part is composed of *strata* of *lime-stone*, reduced, by their fractures, into terraces, one below another, down to the level of the water, a high *chalk* hill rises on the northern side, forming towards the sea lofty cliffs of *chalk*; and ridges of both these different kinds extend themselves inland, embracing between them a large vale covered with meadows, the lower extremity of which forms the head of the bay.

653. The small town of *Swanage*, where I landed at half past four, is situated at the foot of the *lime-stone* hill behind *Peverel point*, and extends itself along the side of the bay, and a part of the vale. Immediately on my arrival, I set out on foot to view this bay. At the point where it turns, and where its border is formed by the lower extremity of the vale, there cut off in small cliffs, I crossed a brook, flowing through the meadows, along the foot of the *lime-stone* hill. I followed these small cliffs, which are a section of the soil of the vale; their greatest height is about fifty feet, and their base consists of strata of a reddish *sand-stone*, covered with sand of the same colour. These strata also have undergone catastrophes; for they are seen to incline towards the north, and finally to disappear under the strand; so that, near the *chalk* hill, the low cliff at the bottom of the vale is composed of sand alone. I was told by the workmen in the quarries, that the *lime-stone* *strata*

strata of the southern hills, descending towards the vale, pass under its *strata* of *sand-stone*; and at *Swanage*, Captain Lewis, of the sea fencibles, informed me, that, from sea, the *strata* in the cliffs of the *chalk* hill are seen to descend in the same direction, towards the bay following this on the north-east.

654. From the observation of such phenomena as these, it cannot occur to the mind, that *bays* have been formed by the actions of the *sea*, and the *vales* coming down to them excavated by *running waters*. What subsidences and angular movements must all these *strata* have undergone, to produce such disorder as I have here described! The sea is so far from having formed this *bay*, that it is tending to fill it up, as is the case with all others: the strand under the low sand-stone cliffs consists of sea-sand almost pure, and extends itself beneath the water with a gentle declivity; it is here that the bathing machines are kept; and at the foot of the cliffs the waves have formed a very wide beach, composed of *siliceous* gravel, excepting near *Swanage*, where this is mixed with *calcareous* gravel. As for the quantity of the water which passes through this wide vale, I have mentioned a brook flowing along the foot of the lime-stone hills. In following the cliffs of sand-stone, I crossed another rivulet on the beach; and when I came to the chalk hills, I saw a third, which issues from an interval between the foot of those hills and the soil of the vale, and is so small, that it

loses itself in the gravel. It is therefore every way impossible to ascribe this *vale* to the action of *running waters*.

655. The lower part of the *chalk* hill on this side has no great declivity, and its base is cultivated; but above, it rises very rapidly. I began to ascend it in the interval just mentioned, following the sheep-tracks; and I crossed the cultivated part from field to field; but after this, the hill, covered only with a turf formed on the rubbish of the *chalk*, became so steep, that, finding myself much fatigued, and still far from the summit, I was going to give up my attempt, when I perceived at some distance, nearer the sea, a row of white patches in the turf, beginning from a lower part, and reaching the top. I went towards this, judging it to be a kind of path, formed by the footsteps of the country people. It proved extremely troublesome to cross obliquely the rapid declivity of the hill; and when I came to the path, or more properly succession of holes, I found them at a great distance from each other, the vertical rise of each step being at least a foot; but, as the weather was dry, and I had a firm footing at the bottom of these little cavities, I was here able to ascend the hill: its extremity towards the sea, which is lower than the rest, is entirely overspread with the flints belonging to the chalk; but the quantity of these diminished as I ascended, and the top was covered with turf.

656. This ridge of *chalk* hills, coming down from the interior part of the country, and terminating in cliffs towards the sea, forms the separation between *Sandwich bay* and *Studland bay*, in which latter is the *gulph of Poole*. At the extremity of this hill towards the sea, there is a signal post; I went up to it, and having made myself known to Mr. Lowe, a lieutenant in the navy, who commanded there, he was so good as to accompany me, along the edge of the cliff, to a point which overlooked the whole extent of *Studland bay*, and was immediately above the cape called *Fore-land*, or *Handfast point*. This is a cape much resembling that of the *Needles* in the *Isle of Wight*, parts of it having been detached in the same manner, in consequence of crevices in the *chalky* strata; the pyramid nearest the cape is not pointed; it is flat at the top, and covered with grass. Mr. Lowe told me that old men remembered the time when it was possible to cross over to this summit on a plank; but the distance is by far too great at present, as the cliff has crumbled much away. This cliff affords another example of what I have said respecting the difference in the effects produced on coasts, arising from that in the original depth of the sea before them. A *beach* has been formed under the chalk cliffs to the west of *St. Aldham's head*, where the sea is shallow, and they are beginning in some parts to be covered with grass. Here, on the contrary, the sea is still very deep at the foot of the cliff; so that all the masses which fall from the latter disappear in the water, and a long time must pass

before its demolition will be terminated by a *beach*.

657. When I was ready to return to *Swanage*, Mr. Lowe showed me a path very steep, but safe, which, after following for some way the brow of the cliff, descends obliquely towards the head of the bay. In going down by this path, I saw on the opposite side, the slope of the hill composed of the *lime-stone* strata, where heaps of rubbish indicated the entrances of the quarries. I had a view, also, of a great part of the vale terminating at the head of the bay, and interspersed with hillocks, which shew the disorder of the *strata* of reddish soil composing its bottom; a disorder already indicated by the inclination of these *strata* in the cliff in which it terminates towards the sea; and in the sequel will be seen other positions of the same strata, rendering the catastrophes of the different kinds of *strata* in this part of the country too complex, to permit any distinct idea to be easily formed of them.

Aug. 16*th*. I staid this day at *Swanage*, to visit the quarries. Two principal *strata* are worked in them, one of which splits into flags, like that already mentioned in the cliff on the coast; the other is taken out in large masses, and used as free-stone. I learnt that it was not above fifty years since quarries had been opened on the slope, the same stones having formerly been taken from the top of the hill; and this determined me to ascend thither first. When I had reached the summit, I found it to be longitudinally intersected by a *glen*, terminating, like a *combe*, at the highest point. It cannot be doubted that a great subsidence of the *strata*, from the highest to the lowest, has here taken place, while, at the same time, a large mass has become inclined, dipping down towards the vale; for a great section of these strata is seen in the glen on that side; and it is here that there were formerly quarries of the same stones as are now obtained on the slope: these strata extend towards the highest part of the hill; and I saw in several places heaps of the rubbish of the old quarries, only one of which is now remaining, because the expense of the carriage of the stones from hence to the quay has been very much increased, since the farmers, enriched by the tillage of lands before uncultivated, have had sufficient work for their horses at home. It was this motive which led some who had been engaged in the first quarries, and fully understood the *directions* and *inclinations* of the *strata*, to seek the same kinds at a lower level, by sinking on the slope; the first who attempted this having succeeded, others followed their example; and thus the principal quarries are at present here.

658. Before I speak of the two sorts of *strata* worked through these openings on the slope, I shall mention a third, distinct from both, the position of which will serve to convey a general idea of the internal part of this hill. One of the master quarrymen conducted me to the spot under which is found this

particular stratum, distinguished by the name of *Purbeck Portland*, because it has some resemblance to the *lime-stone* of *Portland island;* and in fact I found it to contain the same species of *chamæ;* but this stone is harder, and is of a bluish colour, while that of *Portland* is yellowish. My conductor shewed me a broad terrace on *Durlstone head*, a cape forming one side of the small bay of *Durlstone* whence this stone was taken. This terrace is separated from the hill by a *glen*, into which I descended; but I could not discover any trace of what was there covered by the grass growing on a deep loose soil. My guide then told me that this was a *fall*, (a sinking,) extending through the whole thickness of the hill; and that here ended the stratum of *Purbeck Portland*, which had not been found anywhere beyond it.

659. To give now a general idea of the situation of the two other *strata*, I shall explain the manner of working them on the slope above mentioned. A large vertical excavation is first made, down to the lowest of these strata, one of which, as I have said, furnishes flag-stones, and the other the *free-stone* commonly called *Purbeck-stone*. Between these two there are others, to a considerable thickness, but of no use, because they are too hard for the chisel. For the purpose of working both the useful *strata* by the same opening, this is made wide enough to have on one side a slope down to the lowest stratum, for the extraction of the blocks, the workmen descending thither only by a ladder; a road being cut

on the other side, which leads directly to the uppermost stratum.

660. The materials taken out of this large opening are used to begin the formation of a platform without, on the side of the slope, the breadth of which is afterwards increased by the rubbish of the quarries, and of the stones hewn on it, under sheds, for various purposes. The blocks are brought, from the inner parts of the quarries, to the opening, on small carts with iron wheels, along a road paved with flag-stones: the blocks from the upper quarry come out directly on the platform; but those from the lower can come only to the foot of the inclined part of the opening. This part is also covered with flag-stones fastened together with cramp-irons, and at the top there is an iron pulley, over which passes a rope, with an iron hook at the end of it; this rope is fastened to a windlass, strongly fixed in the middle of the platform. There is an iron ring in the front of each of the small carts that bring up the blocks; in this ring is placed the hook at the end of the rope; and the cart, in which the block is fixed firmly with a chain, is then, by means of the windlass, drawn up along the slope: the wheels are of a sufficient height to allow these carts to pass over the pulley when they come to the front of the platform; and being then on flat ground, they are drawn wherever it is necessary.

661. On examining the blocks on the platform, I did not see in them the *chamæ* belonging to the

stratum called *Purbeck Portland*; I found only some small *gryphites* on the surface of the stratum. But looking at two blocks which lay near each other, I saw on the side of one of them a large *fish*, unluckily without its head, and on that of the other, its impression. I desired the workmen to detach both these pieces, and to send them for me to *Weymouth*, where I accordingly received them; and they are at present at *Ashfield* in *Devonshire*, in the cabinet of Mrs. M. A. Burges, whom I shall have occasion to mention hereafter. This fish is nearly a foot in length, from the point where the head is wanting to the end of the tail, and seven inches in breadth at the point where the fins are fixed; at first sight, it might be thought to have preserved its scales; but it is the flesh itself which has that appearance, being converted into a brown hard substance, consisting of small flakes, forming a kind of mosaic, and easily separable.

662. The master quarryman led me into the quarry whence these large blocks are taken. This stratum is called *down vein*; because, as my conductor told me, it had been first worked on the *downs* at the top of the hill: this directly shews what is here the state of the *strata*; nor are the following circumstances less interesting, as geological monuments.

663 Two of these circumstances greatly facilitate the working of this *stratum*; and the first will afford a new

a new example of the phenomenon already opposed to the Huttonian theory of the *consolidation* of our mineral strata by an *internal heat*, namely, that *soft* strata are often found between the *hard* ones; now here, the stratum of *lime-stone* which is worked is separated from a lower stratum also of *lime-stone*, by one of *soft marl*, about a foot thick, whereon the former rests. The other circumstance, equally favourable to the workmen, is that the whole mass is intersected by *fractures* in two different directions, *longitudinal* and *tranversal*. By these two circumstances, the *blocks* are already formed, within the quarry, of a proper size to be taken out; they are irregular parallelopipeds, and have all the same thickness, viz. that of the *stratum*, which is several feet; the other dimensions depend on the distance of the fractures in both directions. When one of these blocks is to be detached, nothing more is necessary than to dig under it, in order to remove the soft marl on the most convenient side; and it then separates from the rest, and falls on that side. In every quarry, they begin by taking out the blocks along one of the longitudinal fractures, leaving some here and there, as a support to the *roof*; but when they have proceeded a certain way, they extend their work in breadth, by taking the blocks on several of these lines; in order to increase as little as possible the distance from the opening of the quarry.

664. The road along which I went within the quarry will again show some very interesting phenomena, relative to the effects of the catastrophes un-

dergone by the strata. The general method of working in these quarries is to follow the direction in which the strata rise; because thus, when the blocks are detached, they are the more easily drawn on the small carts towards the opening. The master quarryman and one of the labourers led me into the quarry with lamps. For a certain way, the *floor* rose; but it had, at the same time, a lateral inclination, which fatigued me very much; for though, where the blocks have been taken away, the stratum of marl is covered with flag-stones, yet, as this marl is soft, the weight of the blocks makes some of it ooze out in the intervals between the flags, which renders them extremely slippery. However, these quarries are attended with another great advantage; and this is, that, from the many vertical fractures through the whole hill, the water dropping from the *roof*, soon passes through the *floor*; so that it does not lie there, but only produces some dampness in the quarry.

665. At a certain point, I found the *floor* of this gallery become suddenly *horizontal*, that is to say, without either ascent or lateral inclination; and it had been already worked a considerable way in this position; but the workmen told me that, from their own experience, they expected soon to meet with another sudden change produced by a fracture, and to find the *stratum* either higher or lower, perhaps in a great degree: they showed me, in our way, several less considerable changes of its level and inclination, occurring after fractures; and always, in

this case, the fissure, which is very wide, is filled with some extraneous matter, like the *false veins* in mines. Thus, in the transition from the ascending and laterally inclined planes of the strata, to their horizontal position, there is a fissure of great breadth, filled with soft clay.

666. The quarry-men farther told me, that considerable vertical separations, filled with semi-transparent stalactites, are occasionally found between the masses of strata; and that in parts where the vertical fissures do not pass directly from stratum to stratum, subsidences of some intermediate masses have taken place in the lower strata, while the upper have remained supported by the sides. This is the origin of all *caverns*, which are more frequent in calcareous mountains, than in those of other kinds; and I learnt from the master quarry-man, an elderly man, that caverns of considerale size have been found in other parts of this hill, with springs passing through them, which afterwards break out at the surface. Advantage has been taken of a spring of this kind to the north of *Swanage*, for the construction of a mill; a basin has been formed immediately below the point where the spring breaks forth; when the water has accumulated in it, a plug in the bottom, near the anterior edge, is taken out, and the water falls on the wheel; the plug is replaced, when the basin is emptied, and as soon as it is replenished, the operation begins again. Such springs can be produced no otherwise, than by the accumulation of the water

in interior *caverns*; of which some greater examples will be seen in these travels.

667. I have given this circumstantial description of both the internal and external parts of the hill at *Swanage*, because it will serve as an example of what I have said in general respecting the formation of *hills*, (as well as of *mountains*,) and of their intervals, the *vales*; I mean, that they are *original forms* of the *continents*, produced by the catastrophes of the *strata* on the bottom of the ancient sea: and hence may be understood why, in describing the external appearance of hills, I so frequently mention surperficial *inflexions* of their summits; since these inflexions, which cannot, in such a situation, be attributed to exterior causes, shew an internal disorder of the *stony strata*, produced by their fractures and by the angular motions of their disunited masses, which the loose external soil, cultivated, or covered with grass, conceals from view. It has been seen in this hill of *Swanage*, that a simple *inflexion* on its brow marks a point, where the *stratum* of *Purbeck Portland* is cut off, and beyond which it appears no more; that an *inflexion* on the summit discovers *strata* which are also found on the slope; and that, with such small external signs, the whole mass of the *strata* within the hill is fractured and disordered. The soil of the vale, and that of the *chalk* hills on its northern side, cannot be examined with equal advantage, because there has been no inducement for piercing them; but it will be seen, that their forms announce no less evidently the catastrophes by which these external appearances have been produced.

Aug. 17*th.* I hired a horse at *Swanage* of a man who was to accompany me on foot, both to serve me as a guide, and to take back the horse when I should want it no longer. My design was to go to *Studland bay*, and thence to *Poole harbour*, which opens into it: the horse way was first up the vale, as far as an intersection in the ridge of the *chalk* hills, wherein *Corfe Castle* is situated, and whence there are two roads to the bay; one along the foot of the chalk hills, on the opposite side, and the other over their top: I took the latter road, purposing to return partly by the former.

668. I found the soil of the vale interspersed with those hillocks which I had observed from above, and which, in some parts, rise on the foot of the bordering hills, indicating the disordered state of the *strata* of the *reddish soil* beneath the turf. When I came to that interruption of the *chalk* hills just mentioned, in which *Corfe Castle* stands on a small eminence, I saw on the left a high insulated hill of *chalk*, divided, from top to bottom, by a *combe* with very steep sides: rubbish of a *chalk* sufficiently hard to be used in mending the roads is taken from its foot. It will be seen, in the course of these travels, that the lowest *strata* in the *chalky* eminences are very generally the *hardest*.

669. I did not at this time stop at *Corfe Castle*; but ascending the *chalk* hill separating the two bays, I proceeded upon it in a retrograde direction towards

the sea, nearly to the signal-post which I had visited two days before. The slope of this hill is much less steep on the side of *Studland bay* than on that of *Sandwich bay*, and its lower part is cultivated: near its foot, I found a small longitudinal vale, dividing it from an interrupted ridge of hills running along the foot of the *chalky* eminences. I ascended the nearest of these mounts, and found it to be composed of the same *reddish strata* which form the bottom of the vale on the side of *Sandwich bay*; those of *sand-stone* being covered with sand, and in great disorder. This stone is called *grit* in the country, and some of its *strata*, which are of various colours, are hard enough to serve as grinding stones; its scattered fragments are strewn over the whole slope of the hill; and, from the aspect of the place, it may be concluded, beyond all doubt, that such a chaos cannot have been produced by any cause in action on the continents, since they have existed.

670. The village of *Studland* stands on the foot of this hill; and lower down is a very wide strand, extending southward to *Foreland point*, and bordering the whole bay up to its northern cape near *Christchurch*, being interrupted only by the entrance of *Poole harbour*. Beyond *Studland*, on the latter side, the strand runs along the foot of a ridge of low hills branching off from those by which I had descended thither, and encompassing a great part of the gulph; it appears even, that the subsidence of a part of the strata of this ridge, below the level of the water,

has been the cause of the continuation of the strand, as far as the channel which the tides have preserved for themselves in the enclosed gulph; that channel forming the entrance of the harbour.

671. The sediments of the land-waters being almost entirely retained within the gulph, while the small portion of them issuing with the tides is carried out to some distance, this wide strand is composed of pure sea-sand, with the little gravel which the waves have found in their course; so that the winds have formed a row of *dunes*, resting against the feet of the hills, except in a part where, the original bottom of the sea having happened to be lower, the high tides still fill a space, which, in the county maps, is called *Little Sea.* The tide being much risen when I camo to this space, I took my guide upon the horse behind me till we had crossed it: there are no dunes here against the foot of the hill, because the strand itself is interrupted; but they begin again beyond this, and go on to the end of the slip of land called *Rathorn point,* about five miles distant from *Studland.* There a passage boat is kept, in which I crossed the entrance of the gulph; and I landed on a continuation of this slip of land, extending as far as the hills on the northern side.

672. This part of the slip of land appears also to have been formed on a submarine bar, beginning from these hills; and the sea has doubly contributed to increase its breadth. On the outer side, so large a quantity of sand has been driven towards the coast,

that it has formed *dunes*, indicated in the map under the name of *Sand-hills*. Within, where the sediments of the land-waters are retained by this bar, the waves and the tides have formed a broad strand, now covered with grass. The *dunes* bordered on the inner side by this strand are so wide, that, being overspread with heath and furze, they maintain a flock of sheep, belonging to a farm-house, which stands there. In my way to *Poole*, six miles from hence, I turned to the west, and proceeded along the foot of some hills, of a nature quite different from the three kinds already described on this side of *Swanage*; these belong to the ridge which I had crossed in my preceding journey from *Poole* to *Christchurch*, (§. 594,) and which, so far as can be perceived from their abrupt sections, are composed of *sandy* strata, some white, and others yellowish, intermixed with strata of *white clay*; the surface being covered with *siliceous gravel*. There are in the gulph several *original islands*, consisting, as I was told, of the same soil with the latter hills, and the vale terminating at the gulph: the principal of these is *Branksea Isle*; part of it is cultivated, and the rest planted with fir-trees. The ridge of hills which I followed has several branches advancing into the gulph; and there are very extensive new grounds on this side, already beginning to be green at low water, though they are still covered by the high tides, except in the creeks, where they are become pastures. In one of these creeks, between the *Salt-office* and *Parkson*, salt is made in the same manner as at *Lymington*.

673. At *Parkson*, the road quits the shore, to pass over a promontory, before which, as it advances farther into the gulph, there is not yet a solid strand; its sides have continued longer abrupt than the parts less exposed to the waves; but by degrees, as the new lands have been formed against them, these cliffs have been reduced into slopes, and covered with grass, remaining abrupt only at its extremity. Before I arrived at *Poole*, I passed over several other promontories, crossing the intervals between them on the new lands. In front of these lands, there are two spaces with farm-houses on them, which, at high water, appear to be *islands*; but they are probably, at low water, united to the coast. I crossed one of the creeks to arrive at the promontory, already described in §. 593, on which *Poole* is situated; and I entered the town nearly in the middle, opposite to the quay where the vessels lie: I arrived there at half past one, and at three I set out for *Wareham*, on the opposite side of the gulph, at the distance of about nine miles.

674. As the tide was going out, I took, in leaving *Poole*, a road over the new lands within the gulph; but, after I had proceeded a certain way, I came to a part still covered with water; and this obliged me to ascend on the original coast, and to follow the high road passing along the borders of the gulph over small hills, most of which are uncultivated. Though the tide had not yet completely retired, I saw the gulph almost entirely occupied with sand-banks, already

ready green in their middle. Towards the sea extends the ridge which, advancing from the *Studland* side encompasses the gulph, and is bordered without by the wide strand above described. I arrived at *Wareham* at seven o'clock; and as I intended to stay there, I sent back the horse to *Swanage*, and began my observations that same evening, with a guide, in order to form a general idea of the place.

675. A promontory of the continental soil advances at the head of the gulph; and across this, at about a mile from its extremity, is built the town of *Wareham*. This promontory separates the mouths of two small rivers; one of these is the *Froome*, already mentioned as passing through *Dorchester*, whence it arrives on the southern side of the promontory; the other, arriving on the northern side, is the *Piddle*, seen from the top of the promontory winding through meadows to a considerable distance. Here, as we have found to be the case in many other places, the vale in which the river flows is so far from growing wider as it approaches the sea, that it becomes narrower; and of this circumstance advantage has been taken for the purpose of raising the level of the water by a dam, that it may fall on the wheel of a mill.

676. The *Froome* issues also from a large vale covered with meadows; and at its original mouth there was formerly a port as much frequented as that of *Poole*; but the whole head of the gulph has been

so much filled up by the sediments of land-waters, and the sea-sand driven again the shore by the waves and the tides, that very extensive new lands have been formed here, covered with meadows, through which both the rivers have prolonged their course. But the bed of the *Froome* is at present so shallow, that only small craft can come up to the port, and even these must ascend with the tide. I went to the end of the promontory, where I saw the meadows of both sides meeting before it, and advancing forwards a considerably way; and I was told that they were still continuing to extend themselves.

Aug. 18*th.* Setting out on foot from *Wareham*, at ten in the morning, I proceeded first towards *Corfe Castle*, at the distance of four miles.

677. In going out of the town, I crossed the meadows of the *Froome* on a long causeway with several openings, the principal one for the river, and the others for small rivulets, and for the passage of the waters when the meadows are overflowed. This led me to small hills covered with heath, the soil of which is a white sand, overspread with *siliceous gravel*. Having proceeded some way farther, I came to a large excavation, already very deep, whence is taken *white clay*, used for making pipes and earthern ware, and transported for these purposes to a considerable distance. To carry off the waters from this kind of quarry, a trench has been made, which crosses the

road,

road, and is passed on a bridge. These strata of clay are covered by others of white sand intermixed with yellowish: there is a great deal of *siliceous gravel* on the surface, but none in either of the above two kinds of strata.

678. Between this and the entrance of the opening in which *Corfe castle* is situated, I passed over some low hills on the base of those belonging to the *chalky* ridge; and when I came to the opening, I saw the castle within, standing on an insulated mount, of which it covers the whole summit: it was formerly flanked with round towers; but it was demolished in 1645, during the civil wars, and its walls were in part blown up with gunpowder. The masses of these walls and of the towers, still lying on the slope, may afford an explanation why the word *breccia*, which, in Italian, signifies a broken wall, is, in Geology, applied to certain hard strata, containing fragments of other stones; for the mortar of the fallen masses is so much indurated, and adheres so strongly to the stones, that some of the towers remain entire; and one, which is detached from the wall, leans very much to one side without being broken. I entered the precincts of the castle by a very high bridge, supported by three arches, and passing across a vale: it rests against a hill near the village called *Corfe castle.* On the back part of this hill, an abrupt section of the *chalky strata* shews that their planes, nearly vertical, run across the hill; but in other places, and even in the mount of the castle, the inclinations of

the strata are different; which circumstance very visibly indicates that this interval between the hills has been the effect of a subsidence, followed by angular motions of the divided masses, part of which have remained at a higher level. At the foot of these hills the *chalk* is very hard.

679. The small river *Corfe*, formed in the vales and combes coming down to this opening, divides itself to encircle the mount of the castle, and afterwards, re-uniting, is directed along the foot of the hill, for the purpose of turning a mill; whence it returns to its natural channel, and flows through a vale, which is in one part very deep, and terminates in one of the creeks of *Poole harbour*. I undertook to follow this vale along the summits of the hills on its left side; but I found them so much covered with very high furze and broom, that I gave up the attempt, and turned back.

680. I then came into a meadow, where, being already fatigued by my walk, the shade of a tree invited me to rest. Throwing myself upon the grass on one side, I took my pen and ink and my pocket-book out of my pocket, in order to note down my observations; and while I was writing, with my head bent downwards, and my eyes screened by a hat with a wide brim, which I wore in these excursions to keep off the sun and the rain, I suddenly perceived before me the edge of a muslin gown; I raised my head, and saw a tall pretty girl, neatly

dressed, who said to me, "Pray, Sir, are you ill?" "No, Madam," answered I; "but why do you ask "me that question?" "My mother and I," replied she, "from our house, saw you fall down under the "tree, and not stir afterwards; so we were afraid "that you had been taken ill; and my mother sent "me to know what was the matter, and whether you "wanted any assistance." I was much pleased at such an instance of kindness, and explained to her, that, being fatigued, I might very probably have laid myself down like one who was falling, and that I had remained in the same posture because I was writing. The good-natured girl expressed great pleasure at hearing this; but observing that I was much heated, she invited me to go and refresh myself at her father's house, shewing me, at some distance, the mill which I have mentioned, and telling me that her mother, whom I saw in her garden, looking towards us, would be very happy to receive me. I must have gone a great way back, to have accepted this truly hospitable invitation; I could therefore only thank her for it; but seeing her so obliging, I told her how I had been hindered from proceeding farther, and asked her whether there was any path through the furze along the brow of the hills, whence I might keep in view the vale through which their mill-brook flowed: she replied that there was such a path, and she went on to shew me the entrance of it, telling me, however, that I should find it very fatiguing and difficult to follow; and so in fact it proved, after I had taken leave of her.

681. But the greatest inconvenience which attended this path was, that it frequently turned away from the brow of the hill; and I was then obliged to pass through the thick furze, that I might not lose sight of the vale, where I saw the little stream flowing along, sometimes, as it were, at the bottom of a green cradle, the grassy sides of the hills coming down to its edge; sometimes through small horizontal meadows; but in no place did any trace of erosion appear. From one part of this elevated border of the vale, I saw at a distance, near the top of a hill on the other side, a row of heaps, which seemed to consist of the rubbish of quarries. I wished to know what it was that was worked there; and ascending an eminence, in order to gain a sight of some habitation, where I might make inquiries, I discovered a farm-house in a cultivated vale, towards which I descended, but there was nobody within. I then proceeded along the vale, till I came to a cottage, where I found a lame old woman, and a young girl. I questioned the former respecting those heaps; but she did not understand what I meant, never having observed the spot where they lay, which was out of sight of her cottage, being concealed by the hill bordering the vale. I begged her to let me take the girl up the hill with me, that I might shew her the object of my inquiry; but she would not allow her to go alone; and as yet she was willing to oblige me, she took her stick in one hand, and leaning with the other on the girl's shoulder, she set out herself before me. When we were come to the top of the

hill, and she could see the heaps about which I had inquired, she told me that, though she had never been on the spot, she knew that *white clay* had been dug there for a long time, and was carried away by sea, and that this clay was followed to some depth below each of the openings which I saw.

682. Here then, at this high level, in a section of the strata of the ridge of hills bordering the coast, and descending from this point, in several terraces, towards the bottom of the vale wherein flows the little stream, we find the same strata of *white clay* which I had seen worked, near *Wareham*, at a lower level; and I learnt afterwards that they are also found under the soil of the vale terminating at *Poole harbour*, as well as in the hill between this vale and that of *Christchurch.* These are very distinct *strata*, and the regularity in their masses shews that they must have been formed in a horizontal and continuous situation: now these masses being nevertheless found dispersed in various places, and at very different levels, we cannot consider *Poole harbour*, and the *vale* coming down to it, in any other light than as effects of *subsidence*; and this is confirmed by the descriptions which I have given of the other hills on both sides. None of these effects can have been produced on the continent since it has existed; they must therefore be *original features* of its surface; and thus the sensible progress of the filling up of *Poole harbour* is among the proofs that the *conti-*

nent cannot have existed during a very great number of ages.

683. In returning to *Wareham,* I followed for some time the upper parts of these low hills, by a path, the unevenness of which shewed the disorder of the *strata* within, though they were concealed from sight by the thick loose soil above them. The ridge of the high *chalk* hills was on my left; and as I proceeded in that direction, I remarked in them a recess, which, when I first observed it from a distance, appeared to me similar to the opening of the passage to *Corfe castle,* where this ridge is interrupted; but, on arriving opposite to it, I perceived it to be only a great *subsidence* of the mass of *chalk* within the ridge; for I saw on the slope, towards the bottom, a zigzag path ascending it, and forming a communication with the farther side of the chain; and the waters proceeding from the sides of this kind of *combe* form at its bottom a morass, whence issues a rivulet: I crossed the latter on a bridge in the high road, which I there re-entered; and I reached *Wareham* at four o'clock. It being my design to return to *Weymouth* along the foot of the eminences of *chalk* in the interior part of the country, I this evening engaged a one-horse chaise, with a guide, for my journey; purposing also, in the course of it, to cross the summit of those hills nearer *Weymouth.*

August 19*th.* I set out from *Wareham* at eight in the morning, and first reascended the promontory separating the latter part of the courses of the two small rivers. I then went down towards the *Froome*, which flows through extensive meadows between the low hills bordering the foot of those of *chalk:* into these meadows the road frequently descends, to avoid turnings; and I proceeded thus as far as *Woolbridge*, about five miles from *Wareham*, where the feet of the hills, approaching each other, have permitted the construction of a bridge; on this I crossed the river, which I left on the right, as I ascended towards the *chalk* hills. Before I had reached the bridge, I had seen from the road *Lulworth castle*, with its park, appearing to form a continuation of these hills, though, as I have said, when viewed from the sea, it is seen to stand on an insulated mount, like *Corfe castle*, in a chasm between the eminences of *chalk*; but the features of the scenery are here on a larger scale.

684. Ascending gradually the slope of the hills, I came to a spot where a small mount of *chalk* rises above the loose soil; and though this spot is eight miles from *Wareham*, and the farmers round that town, where much tillage is carried on, have *chalk* close by them at the foot of their own hills, they come here to fetch it, as dressing for their lands; because the *chalk* at the foot of the hills, belonging, as I have already explained, to the under *strata*, discovered only by the catastrophe common to them all, is very hard, and almost stony; while this mount, being higher, is formed of the upper *strata*, which are soft,

and easily pulverized on the lands; these are the strata that principally contain the flints.

685. The nearer the summit of the eminences of *chalk* is approached, the more does the *loose soil*, composed of sand, and covered with flints, diminish in thickness; till at last nothing remains on the chalk, but the grass growing on its own product, the black vegetable mould. I thus arrived at the village of *Poxwell*, whence I descended, by a steep road, towards *Osmington*. I had now reached the back part of the hills on the coast, which I had not had time to examine in my former excursion. (§ 588.) The vale of *Osmington* lies in the interval between these hills and the *chalky* eminences; but on both its sides appear sections of the *lime-stone strata*; the different inclinations of which shew that a great fracture has here taken place, and has been widened by the subsidence of the *strata* towards the sea. I passed over the ridge of hills on the latter side, and in the descent I saw many quarries on the sections of the *strata*, here forming successive terraces. At the foot of some of these sections, there are small transversal vales, by one of which I came to the village of *Preston;* whence I entered the high road from *Dorchester* to *Weymouth*, and arrived at the latter place at eleven in the morning.

686. I set out again from *Weymouth* soon afterwards, on a journey into *Devonshire;* but as I returned to that county the two following years, and

visited also *Somersetshire* and *Cornwall*, in order not to separate travels connected with each other by many points, I shall first relate, in this place, my observations around another town very much frequented, namely *Bath*.

Journey from WINDSOR *to* BATH *and* BRISTOL, *with Observations in the country around those Cities.*

687. I had already often travelled this road, and visited all the places in the neighbourhood of *Bath*, when my eldest son, who lives at *Geneva*, came to *England* to see me. I took that opportunity of making with him the journey which I am now going to relate. The road from *London* to *Bath* is however so well known, that I shall mention only two particular circumstances respecting it.

June 1*st*. 1805. We set out from *Windsor* for *Bath*. Near *Reading* is a vale of great extent, levelled by the waters, and covered with meadows on a peat soil, where I remarked the same phenomenon which I have described in *Holstein* between *Eutin* and *Kiel* (§. 312.); namely, that the sand under the *peat* is penetrated with its molecules down to a certain depth. At *Reading*, and in the neighbourhood, this *sandy peat* is used for firing; and large heaps of it are also burnt on the spot, because the sandy ashes form a very good dressing for particular lands.

688. The other object which fixed my attention in this road has already been mentioned (§. 528.) as a great geological circumstance; and such it is in many different points of view, as well with regard to the

nature of the revolutions which the surface of the earth has experienced, as to the time during which the existing continents have been inhabited by the human race. It was in reference to this latter consideration, that I was struck, after we had passed *Marlborough*, with the great diminution in the quantity of the *blocks* of *granulated quartz* scattered over *Marlborough downs* since I had observed them in my first journies to *Bath;* and this recalled to my mind a remark of M. DE SAUSSURE's respecting a similar circumstance. In his *Voyages aux Alpes* he introduces a mineralogist observing the *blocks* of *primordial stones* scattered over the space between the chain of the *Alps* and of the *Jura*, and continues thus, (§. 1101.) " He will behold with some interest large " *blocks* of these *débris* dispersed here and there on " the borders of the lake of *Geneva;* for example, " between *Allamand* and *Rolle*. There were form- " erly very fine ones along the high road; but they " have been almost all destroyed, either for the pur- " pose of mending that road, or for building. *It is* " very natural that such uses should be made of " them; but as for me, I cannot see, without a lively " regret, the destruction of such precious monu- " ments of the great revolution to which the surface " of our globe is indebted for its present state. For " if this destruction continues to make such progress " as I have seen during the last twenty-five years; if " the enclosure of lands and the construction of " buildings go on increasing in the same proportion; " it is probable that, in the course of two or three

"centuries, few or none of these monuments will be
" left in our country. This consideration combines
" with many others in proving the truth of an opini-
" on, which I have elsewhere already hinted; that,
" although the mountains, especially the primitive,
" appear to be of such an antiquity as alarms the
" imagination, yet the actual state of the surface of
" our land, its population, its culture, are compa-
" ratively of an almost recent date."

689. This remark is no less applicable to *Marlborough downs.* Passing over these plains in 1780, I had found them, in some parts, so abundantly covered with large *blocks* of *granulated quartz*, that there was very little space for grass in the intervals; while in my present journey, after a similar period of twenty-five years, I saw very few of the blocks remaining in those places. This diminution proceeds from the same causes as are pointed out by *M. de Saussure;* and in a much shorter space of time than is assigned by him, this great monument of the revolutions to which the surface of our globe is indebted for its present state will no longer exist on *Marlborough downs.* As more land is taken into *cultivation*, more *buildings* are proportionally required; these blocks are broken into cubes, and used for the walls; and as they are taken in preference from the spots nearest to the high roads, the parts within the observation of travellers have consequently been the soonest cleared.

690. Such *blocks* were originally dispersed over a great extent of country in this southern part of *England*, particularly in *Wiltshire*, *Hampshire*, and *Berkshire:* from a very early period, they were used for large edifices, such as *Windsor Castle*, and several Gothic churches: and it is also of immense blocks of this kind that the stupendous monument of *Stonehenge* on *Salisbury plain* is formed. These masses were, for the most part, buried in the sand, below the surface; and formerly, scarcely any were used but those which shewed themselves above it; so that there are many still remaining: they are called *heath-stones*, as being found in *heaths;* but as these lands are brought into cultivation, which at present takes place very rapidly, the stones are removed, and at last none will be left but on the tops of the hills. Now here this object assumes another geological aspect; inasmuch as throughout the whole extent of country in which these blocks are found in such great abundance, no *stratum* of their species anywhere appears. I have entered into these details, chiefly because I shall have occasion to refer to them towards the conclusion of these travels, on account of an hypothesis of Mr. Playfair's respecting the origin of vast quantities of *gravel* of the same stone, which are scattered over several counties farther to the north, particularly *Warwickshire and Worcestershire.*

691. I proceed now to *Bath;* but I have visited this place too frequently to enter into full details

respecting all my observations in its neighbourhood; I shall therefore begin by giving a general sketch of the geological objects on which we are here to fix our attention, and I shall then relate such particulars as I observed in the present journey. This whole country chiefly consists of *strata* of *lime-stone*, but of very dissimilar species; the different levels at which the same species are found being *monuments* of the catastrophes whereby *hills* have been formed, (comparatively with *vales* and *plains*,) and shewing how unnecessary it is to ascribe this operation to *running waters*, which, on the contrary, are everywhere seen to raise the bottom of the *vales*. But these *monuments* of revolutions are again, as I shall shew in particular instances, of the number of those which the labours of men are tending to efface.

692. I shall first remark, that a course of observations, which I made in the neighbourhood of *Bath*, in 1787, happened to be at a particularly favourable period; inasmuch as I had an opportunity of observing, especially, on the sides of *Lansdown hill*, *sections* of *strata*, then laid open to view, though before concealed by the rubbish of the slopes; nor was that period of long duration; as the buildings, for which every thing was then in preparation, soon began to cover these spaces, and have been ever since continuing to extend themselves. I shall therefore give a general idea of all that I then observed, though now no longer visible.

693. *Lansdown* is a hill nearly insulated, which, with little breadth in some parts, extends about four miles northwards from *Bath*, and separates two large combes, that of *Charlecombe* on the east, and another on the west, wherein *Weston* stands. In these combes, no streams are formed but rivulets winding through meadows at their bottom; and a proof that they are both the effects of *subsidences* is found in piercing through the rubbish covering the slopes of *Lansdown hill* which come down to them; for when the solid mass is reached, *sections* of the strata are found, produced by fractures at the time of the catastrophe, and since covered by loose fragments of the strata and other materials. These *sections*, as I have said, had been laid open to a certain extent, when I was on the spot in 1787; and I observed the *strata* to succeed each other in the following order.

694. In general, the upper stratum of the hill consists of a hard *lime-stone*, easily divisible in laminæ; this is the same kind which I have described in *Portland island*, and on the low hills near *Bridport* and *Weymouth*; here also it is used for walls of enclosure: when the fragments have been long exposed to the air, their surface exhibits in relief a multitude of small marine bodies, some entire, others broken, and consisting of shells of various species, madrepores, corallines, and the spines of echini, some so small that they cannot be distinguished without a magnifier.

Where these superficial *strata* are missing in consequence of a succession of catastrophes, there remains above the rest a stratum of *white marl;* but neither does this prevail in all parts. The *stratum* which next succeeds is very remarkable, especially on account of its being found in various places at different levels: it consists of concrete masses, formed in a calcareous sand, and mostly in contact with each other; though the sand is loose between them, they are themselves very hard, and in their manner of breaking do not differ, in any respect, from other lime-stones, of equal hardness, in continuous strata. These masses, which are of various sizes, are used for foundation walls: I saw several marine bodies on their surface, and in the broken masses. In various parts of the continent I have seen *strata* similar to this, shewing one of the degrees in the disposition of calcareous substances to *consolidation.*

695. Under the latter *stratum* lies one consisting almost wholly of *sand,* and containing but very few concretions; its sand is not entirely soluble in aqua fortis. This *stratum* covers another which aqua fortis dissolves almost totally, and in which the *concretions,* containing some *marine bodies,* are very large and proper to be cut with the chisel. The *stratum* next under this is perfectly consolidated, like the generality of *lime-stone strata,* and is easily hewn into pieces fit for many uses; it contains a prodigious quantity of sea-shells, mostly bivalves; as chamæ, pectines, cardia, anomiæ; but the *stratum* below it is so hard as to require to be blown in pieces with

gunpowder. Lastly, below all these *strata*, I again saw one which was incompletely consolidated; it separated into irregular masses, and shewed by the difference in the marine animals contained in it, that, after it was formed, the liquid of the sea must have undergone a sensible change, previously to the formation of the succeeding strata: this stratum contained a great quantity of *cornua Ammonis*, very small in some of the masses, where they seemed, as it were, in a nursery bed; while in others there were some at least a foot in diameter; in this stratum I found also abundance of *belemnites*.

696. I have now enumerated the principal *calcareous strata* open to view, when I examined the different parts of the slope of *Lansdown* on the side nearest to *Bath*; these parts being then in preparation for the buildings which covered them in 1805. The above strata incline towards the town, and beneath them lie soft bluish *argillaceous strata:* this is known, in the first place, by the wells dug for the new houses; where, in order to obtain water, it has been necessary to pierce through the *calcareous strata*, down to those of *clay*, and to hollow out cisterns in the latter, in which the waters that filtrate through the upper strata are collected. These argillaceous strata are found at different depths, down to that of 60 feet, according to the parts of the hill which are bored.

697. The effect of this inclination of the strata towards the west shews itself on the eastern part of

this extremity of the hill; for here they have not only been broken, but, either by their sliding lower to the west, or perhaps by the disappearance of great masses below the level of *Charlcombe* to the east, and of the vale of the *Avon*, to the south, the lime-stone strata are missing on this eastern side, where the argillaceous only are found; of the latter is composed *Beacon hill*; a great part of the foot of which had been cut away, when I saw it in 1787, in order to prepare for the erection of a new row of houses; these have been since built, and now conceal all that I then observed. The argillaceous strata are there covered only with a loose soil, consisting chiefly of sand, whence issue the springs, the waters of which formerly ran down the slope in rills; but this covering had been removed in several places along the course of these rills, and reservoirs had been sunk in the clay, whence it was proposed to lead the water by pipes to the future houses. I observed the section of the *strata* in the excavated spaces; I saw in them concretions, some dispersed, others forming distinct strata between the soft ones: both these kinds of strata contained marine bodies, such as belemnites, chamæ, pectines, cornua Ammonis, but in small quantities; I found there also some ochreous geodes of various sizes, the concentric coatings of which were of different shades.

698. Now as all the *strata* above described contain *marine bodies*, which also differ, and even essentially, from *stratum* to *stratum*, and as these *strata* are parallel one with another in their separate masses,

they must necessarily have been formed in a *horizontal* and *continuous* situation on the bottom of the sea, the state of which must have remained undisturbed during a very long period. It has been with a view to this conclusion, and to its consequences, that I have described the several species of these *strata*, (of which others equally distinct will appear in the sequel,) in order that they may be recognized when they shall be found elsewhere, either at different *levels*, or with *inclinations* differing in degree, and turning towards various points of the horizon. For such changes will evidently shew in what manner the *vales* have been formed between the *hills*; namely, by *fractures*, partial *subsidences*, and *angular motions* of the divided masses; by which determination the chimerical notion of the *excavation* of *vales* or *vallies* by *running waters*, a notion leading to so many errors in Geology, will be completely dissipated.

699. *Bath* is a place very much frequented by men of leisure, who seek for amusement in their rides and walks; if any among them, on reading these travels, shall comprehend the importance of avoiding erroneous ideas respecting the *history of the earth*, and how much the present state of the *strata* which compose our continents is connected with that history, it will become an interesting amusement for them to investigate this state, by surveying the hills and vales of this part of the country; familiarizing themselves with the appearance, and observing the different situations, of certain *strata*;

but at the same time retaining in their memory that the parallelism which these *strata* preserve with each other in their several masses, and the *marine bodies* contained in them, constitute a proof that they must have been originally horizontal and continuous on the bottom of the sea, and consequently, that their present situation is the effect of catastrophes. Of these observations, and of their consequences, my narrative of the new excursions which I made here with my son will afford examples; and to this narrative I shall now proceed.

June 15*th*. 1805. We set out from *Bath* on foot, at four in the afternoon, for *Week*, at the distance of six miles. We walked four miles over *Lansdown hill*, to the monument of Sir BEVIL GRANVILLE. At this point the hill turns towards the west; and we had before us a large vale, into which we descended obliquely down a very rapid slope. Near the top, we saw the upper *strata* of *lime-stone* dip towards the vale; but lower down, the slope is so much covered with their rubbish, that they can no longer be perceived. Towards the bottom, however, appears a sign that this side is a section of all the *strata*; for springs issue from the slope, and indicate the section of the *argillaceous* strata, on which the water filtrating through the fissures of those of *lime-stone* being retained, it here flows out through the rubbish, in the same manner as in the instance given in the preceding volume, §. 319.

700. On coming to the foot of the hill, we took

the road to the village of *Week*, near which, in 1787, I had observed an object very remarkable, as well by its picturesque appearance, as by its tendency to enlarge our ideas respecting the strange revolutions of the strata. When we now arrived there, I fancied I had mistaken the place; but I soon found that this was only another example of the manner in which the labour of man contributes to the destruction of geological monuments; a consideration that ought to engage future generations to preserve the exact descriptions of objects, which for them will no longer exist. The *rocks* at *Week* formerly excited so much curiosity and astonishment, that few people came to *Bath* without going to see them. They consisted of a double chain of pyramids, similar in form to the peaks in the *Alps*, and extending across a large vale, the undulated surface of which would have shown but imperfectly the internal disorder of the *strata*, had it not been for such external signs. A brook flowed between them, as is the case between the gigantic pyramids near the summits of the *Alps*. The *strata* of these rocks, dipping under the soil of the vale, consisted of a *lime-stone* very different from that of *Lansdown*, and of the same nature as that of *St. Vincent's rock* near *Bristol*; being a kind of reddish marble. This stone affording a better lime than that in the immediate vicinity of *Bath*, where the buildings have so greatly increased, and pyramids besides being very easily attacked, their demolition was begun soon after I had first seen them, the lime being burnt on the spot; hence, at this second visit, I found the largest of these pyramids razed to their foundation, which was covered with grass; and if the same process continues, this geological monument, so important when we consider the place, the difference between these *strata* and those in the neighbourhood, and other circumstances which I shall soon relate, will at last be totally obliterated.

701. The channel between these two rows of rocks, the strata of which form natural walls on its sides, has afforded the means of constructing a large reservoir of water. A very strong wall twenty feet high, has been built across the space between the rocks, in a part where they approach each other; and this raises the water within the space up to the point, a mile above, where the stream enters it. The water issuing from this reservoir turns a wheel for the use of some forges, and returns afterwards into its natural bed.

June 16*th*. We set out, at nine in the morning, from *Week*, where we had slept; and continuing our journey on foot, we proceeded first towards *Clifton*, at the distance of nine miles. If, in many places, human labour has destroyed geological monuments, it has, in still more numerous instances, discovered to our view such others, as, belonging to the interior part of the soil, would else have remained for ever unknown. This is the case with respect to *coals*; a bed of which is in the district called *Kingswood*, extending from near *Week* towards *Bristol*: we passed near several coal-pits, but without stopping there, because in my journey in 1787, I had paid much attention to them, and particularly had conversed a great deal with one of the proprietors, who was very well informed; I shall therefore now relate the circumstances which I learnt from him at that time.

702. The pits are here sunk on the part of the bed of *coal* nearest the surface, within the extent of the ground belonging to one proprietor: there are places where the edge of the bed, covered only by a greater or less depth of loose soil, *bassets* out near a section of the same kind of *lime-stone strata* as that of the rocks at *Week*; the bed itself leaning against these strata, and dipping with them inwardly, but not with the same degree of inclination; that of the *lime-stone* strata being about 75°, while that of the bed of *coal* nowhere exceeds 45°, and sometimes becomes much less. This change in the inclination of the latter proceeds chiefly, from *fractures* and partial *subsidences*. These catastrophes, however, when they took place, could affect only the strata then existing, on the ruins of which new *strata* were subsequently formed; and this shews how long the strata constituting the perceptible mass of our *continents* must have been covered by the sea, before it retired from them.

703. This is the reason why the state of these *hard strata* in the interior part of the soil is not marked by any external appearance; the surface being so far from parallel to the bed of *coal*, that, after the latter has been met with in some places at a very small depth, in others it lies 120 fathom below the surface; and there it is no longer followed, as the working

ing it would be attended with two much expense. In sinking in parts where the bed of *coal* is at a moderate depth, there is first found a greater or less thickness of *reddish marl*, under which are strata of *petrosilex*: below these commonly lie other strata of *marl*; but at last appear *argillaceous* strata, more or less hard; and these announce that the bed of *coal* is near. In the lowest of the latter *strata, ferruginous concretions*, a very good iron ore, are found, sometimes to a great extent, sometimes in separate masses: these already contain impressions of *plants*, and, in some places, of *marine bodies*. At last, when the *coal* is very nearly reached, the numerous impressions of *plants* on the *schistose* strata immediately covering it afford a certain proof of its vegetable origin; and, at the same time, show manifest symptoms of the great changes that happened on our globe subsequently to the formation of these *peat-mosses*, which, passing under the waters of the sea by catastrophes explained in my preceding works, were there mineralized into *coal*; for the greater part of the *plants* whereof we see impressions on these schistose strata are no longer found in our climates, and others are absolutely unknown among the living species.

704. The fractures and partial subsidences, which occur in the beds of *coal*, form one of the greatest obstacles in working them. In this county, the name of *baiks* is given to the fractures, which, in *Staffordshire* and *Shropshire*, are called *faults*; the colliers being there stopped, as they no longer meet with the coal in their way. The *faults* commonly follow a certain

course in the same district, which facilitates the means of again finding the bed of coal beyond them; but this varies in different districts; so that the collier, who has had great experience in one, has a new study to begin when he removes into another. These fractures, occasioned by partial differences in the subsidence and angular motion whence has resulted the inclination of the bed, cross it in different directions; so that the colliers are stopped in this manner, whether they are following the bed along its declivity, or laterally at the same level. In every district, the collier ought to know distinctly all the *strata* above and below the bed of *coal*; and if, possessing this knowledge, he bores through the extraneous substance by which the fracture, of whatever breadth, has been filled, he may judge, by the substance of the *strata* presenting themselves beyond it, whether the bed of *coal* is above or below this point, and what is its vertical distance thence, and may thus be enabled to find it again.

705. After having pointed out to me, on the surface of the ground, several places, externally distinguished only by slight undulations, where, however, there were very great changes in the bed of *coal* within, with respect either to its absolute level, or to its relative depth below the surface, my informer added this reflexion; "could any one suppose, from the "outward appearance of this ground, that all its "interior strata were in such disorder? Certainly "there must have been very great revolutions in the

" surface of the earth!" This is an idea which must naturally occur to the minds of all who are acquainted with the interior part of the soil; and though, in the rocks at *Week*, and in the connexion between their *strata* and the bed of *coal*, the district of *Kingswood* presents a very remarkable assemblage of circumstances, the phenomenon of beds of *coal* rising and leaning against *lime-stone* strata is not rare; I have seen it in various places, and particularly in *Staffordshire* and *Worcestershire*, at *Dudley* and *Bewdley*. It was by the combination of these phenomena that I was led to the system first explained in my *Lettres sur l'Histoire de la Terre et de l'Homme*, and confirmed by all my subsequent observations; namely, that our beds of *coal* proceed from *peat-mosses* which existed on *islands* in the ancient sea, and which subsided there during the catastrophes frequently recurring on its bed, long the scene of those revolutions before it became our present continents.

706. Another change which had happened in this country, since my former visit to it in 1787, is also a kind of chronometer of the human race. At that period, there were still many places where copper ores, from *Anglesea* and *Cornwall*, were smelted, and a part of their product was made into brass, with the lapis calaminaris found in the neighbourhood. The ores were brought hither, because coals were abundant, and labour cheap; and these works were carried on for some years after I saw them;

but they are now at an end; so much *coal* having been dug out, that the pits are at a depth which greatly increases the expense, while, at the same time, the extension of enclosures has raised the price of labour; so that these smelting works have been transported into *Wales*, where the *coal* is not yet so much exhausted.

707. The waters of all this district, collected in a small stream, flow along the foot of the high hill extending from hence to *Clifton*, on the northern slope of which is built part of the town of *Bristol*. We passed this stream at *Baptist mill*, where its breadth is inconsiderable; in its way towards the *Avon*, into which it falls above *Bristol*, it flows in many parts through meadows, its course having been raised by dams, in order to render its water serviceable for other mills. Near *Baptist mill* appears the section of a very thick stratum of *red clay*, used for making bricks. Above this stratum is found one of reddish *sand-stone*; but all the upper part of the hill, to a great breadth, as far as *Clifton*, and *St. Vincent's rock*, which, at the *Hot Wells*, rises above the *Avon*, consists of the section of *lime-stone* strata, dipping inwardly, of the same species as those at *Week*, and associated, in some places, with strata of *sand stone*. My nephew studied the latter very attentively near *St. Vincent's rock*; and his observations, of which I shall give an extract, will add some new and interesting circumstances to the history of the ancient sea.

708. This rock is a mass of strata, inclined about 45° towards the valley of *Bristol*: the highest of them, in their present state, are of the same *lime-stone* as the rocks at *Week*, hard, reddish, and containing cavities lined with crystals of quartz; but over these, originally, there were strata of *sand-stone*, which, having been thrown on one side by the angular motion of the whole mass, now lean against the former at a lower level. My nephew followed the foot of these *sand-stone strata* behind *Granby Place*, near the *Hot Wells*, where their inclination brings them successively to the same level; and the following are his observations.

709. The first, and originally uppermost, of these *strata* are of a *sand-stone*, of which the grains are from $\frac{1}{300}$ to $\frac{1}{100}$ of an inch in diameter; these grains are of a transparent quartz, forming, by the simple adhesion of contact, without any appearance of *gluten*, a stone so hard, that it strikes fire with steel, and a large hammer is required to break off a few small fragments, even from the angles: the *strata* thus indurated are of a greyish colour. The next, which are less hard, are yellowish; and my nephew, having observed the latter with a microscope, remarked on their grains a ferruginous coating, that prevented the immediate cohesion of these grains in the points of contact.

710. On the surface of fragments of both these strata, he perceived some very neat and regular lines, appear-

ing

to have been made by the incisions of a very sharp instrument. Some of these lines were strait, others curved; and their length was from three to seven-tenths of an inch. It evidently appeared that these were impressions of certain bodies; but he could form no idea respecting those bodies, till he came to a *stratum* in which the sand was loose; and there he found a multitude of fragments of a *bivalve*, probably a non-descript among fossils. All these fragments were garnished with *spines*, of the same forms as the impressions which he had seen on the stones; consisting of small pointed tubes, placed without any appearance of determinate order, either in their arrangement, or in the direction of their curve, and so near together, that he counted seventy on a fragment, the surface of which was scarcely half an inch square. He found none of these shells entire; but the form of the hinge, equal in breadth to the valves, and that of the fragments of those valves, assisted him to compose one; it was in the shape of one of the clasped purses with a large opening closed by two strait pieces of metal of its whole breadth, fitting into each other when it is shut: the valves had a deep inflexion down the middle, on each side of which their surface was convex, and slightly channelled, the lines diverging from the centre of the hinge: the individual thus composed of the pieces on the whole most congruous, was about an inch square on the surface, and both its valves were equally covered with spines.

711. Continuing his examination of these strata in a direction towards those of the reddish marble, my nephew found, next to that which I have just described, some strata of thin *lime-stone*, separated by laminæ less hard suffering decomposition from the air. These strata contain another *bivalve*, appearing to be also a non-descript among fossils, and no less different than the preceding from all living species: of this he found separate valves, all nearly of the same size, not exceeding nine-tenths of an inch in diameter; these are more convex than hemispherical; they have a straight hinge, of their full breadth, forming ears, and are slightly striated with some tubercles. Beyond these last *strata*, and before he came to those of the reddish marble, he found strata of a very different species, consisting of petrosilex, mostly reddish, but some grey; each stratum being about an inch in thickness.

712. This is another detailed example of the monuments still extant of the *history* of the *ancient sea*; for the situation of the *strata* here described, connected with what I have already related respecting the country between this place and *Lansdown*, presents an assemblage of phenomena, which no cause acting on the continent since it has existed can have produced. These different *strata* observed behind *Granby-place*, inclining, as I have said, against those of reddish marble in *St. Vincent's rock*, are parallel with each other, and contain *marine bodies*; they must consequently have been formed in a horizontal

and continuous situation : now here they are not only seen at a lower level than those which originally they must have covered, but they form, as it were, an insulated mass in this country, where symptoms of strange catastrophes in the *strata* every where appear, as will be shewn by the detail of our observations in the rest of this little tour, to which I shall now return.

713. The small river *Avon*, after having passed by *Bath*, (where I shall describe it in a future excursion) arrives from the eastward at *Bristol:* it here forms an elbow before it enters a defile between rocks, in its way to the *Bristol channel,* into which it discharges itself at a point not much below the vast *æstuary* of the *Severn.* This course I shall now follow; nor must my readers be weary of details; for, besides that topographical descriptions are always, in some degree, useful and interesting, it is by them only that Geology can be cleared from many errors resulting from superficial observations, in which it has been long involved.

714. If rivers had formed vallies by erosion, the same *strata* would always be found on both the sides of the latter; and this, indeed, is supposed by Mr. Playfair to be actually the case: now among the multiplicity of examples to the contrary, one already presents itself at *Bristol.* The right bank of the *Avon* is here formed of the *strata* just described, while its left bank consists of a *red soil,* in which

hard strata are intermixed with *soft*. I shall frequently have occasion to mention this soil in my future travels, it being of great extent in the western counties. The tides ascend to *Bristol*. In a former journey I had seen ships aground here at low water; but a canal had since been cut through the *red strata*, and the vessels entering it at high water were kept afloat, by a sluice, along a quay belonging to the town. Besides, a new enterprize was now begun, of great importance to this port, where, if a number of ships arrived together, some were obliged to remain aground below the town, and when the tide was out, they sustained some damage, as well from the pressure of their cargo against their sides, not then borne up by the water, as from their being thus alternately in the water, and exposed to the sun. It had therefore been undertaken to excavate a large basin below the town; and when the vessels shall have entered this at high water, they will be kept afloat in it, by closing a sluice, as they now are in the canal.

715. The excavation of this basin afforded us an opportunity of observing the nature of the horizontal soil covered with meadows, which extends as far as the foot of the hills composed of the *red strata*. This soil consists of the accumulated sediments of the land-waters, and the sea-sand brought up by the tides. The very extensive commerce enjoyed by the city of *Bristol*, notwithstanding its distance from the sea, arises from its situation at the head of an *estuary*, which however, like all others, has thus begun to be

filled up; and it has hence become necessary to have recourse to the means above described. How then can the *Avon* be supposed to have opened for itself a passage through the *calcareous* rocks enclosing its basin on the side next the sea? while the river, before it arrives there, being already reduced to the level of the sea, has no longer any motion but that of the slow ascent and descent of the tides. But it will be seen by the following observations, that this defile has been produced by the catastrophes of the *strata*, as well as the channel between the rocks near *Week*, consisting of the same *strata* which I have already described.

June 17*th*. We took a boat at half past ten in the morning, to go down the æstuary with the tide as far as *Pill*, a port situated on its left bank, where vessels passing up to *Bristol* are obliged to stop, if they arrive there at low water, and to wait till the tide comes in.

716. In passing along under *Clifton*, before we entered the defile, we had on the right the lofty rock of *St. Vincent*, the top of which is covered only with downs; while on the left we saw a section, indeed, of the same *lime-stone strata*, but at a much lower level, with a very thick loose superficial soil, partly composed of rubbish, and towards the upper part clothed with wood; at the same time that these *strata* are seen, in their lateral sections, to incline, on both sides of the defile, in a direction opposite to the chasm.

717. This is already very contrary to Mr. Playfair's idea respecting the origin of the *defiles* in *mountains* through which *rivers* pass. He says on this subject, p. 105, "The *philosopher*, who has *deeply* "*meditated* on the effects which action, *long conti-* "*nued*, is able to produce, and on the simplicity of "the means which nature employs in all her opera- "tions, sees in this nothing but the *gradual* working "of a *stream*, that once flowed as high as the top of "the ridge which it now so deeply intersects, and "has cut its course through the rock, in the same "way, and almost with the same instrument, by "which the lapidary divides a block of marble, or "of granite." Here Mr, Playfair requires this *deep meditation on the effects of action long continued*, because, for the defence of the Huttonian theory, it is necessary to reckon by *thousands* the centuries which have elapsed since *running waters* began to act on our *continents*. He is undoubtedly in the right in considering as an unwarranted opinion the only one that he cites as contrary to his own idea; namely, that "some great *convulsion* of nature has "*torn the mountain asunder*, and opened a *passage* "*for the waters*;" but he ought to have replied to those who have attributed these openings in our *mountains* to *convulsions* of the *strata*, while yet under the waters of the *sea*, before it abandoned our *continents*; and instead of referring us to the *defiles of Altai*, which so few are likely to have seen, he ought to have cited *defiles* within reach of many of his readers; and had he observed these himself, he might

frequently

frequently have seen, not only in the defile near the *Hotwells*, but in others that I shall describe in the sequel, the characters so evidently impressed by that cause of their production, which I have already pointed out, namely, the catastrophes undergone by the strata.

718. As we sailed through this *defile*, we found it not only winding, but with great differences, both between the two sides when compared together, and between successive parts of each side. With respect to the latter circumstance, we saw, in some places, naked rocks rising on the border of the channel, and in others, slopes coming down to it covered with wood; so that, by the turns of the defile, we appeared to be passing from one lake to another, the picturesque aspects of which were continually changing: nor did we find less dissimilarity in the comparative form of the sides; that on the left is intersected with transversal vales, evidently produced by the fractures and angular motions of the *strata;* for the side of these vales nearest the sea is formed by the inclined *planes* of the *strata*, and the opposite side, in many places, presents to view their *sections*. The lower parts of these vales were originally branches of the great *æstuary*, which ascends as high as *Bristol*; but they are now filled up, and covered with meadows: a causeway forms the road on that side, and, being higher than the entrances of the vales, it serves, at the same time, as a dike, to prevent the high tides

from entering these meadows, which, without it, would still be inundated.

719. After a certain space the hills becoming lower on both sides, we began to have a view of the adjacent country; and the sections of the sunken *ſtony strata* appearing above water, we saw them first inclining downwards on the side opposite to the sea, and then becoming horizontal. At last, these strata disappear on the right bank, considerably the lowest of the two, and descending in a slope quite to the level of the water; but, on the other side they shew themselves as far as *Pill*, where their section resembles a wall, and rises about ten feet above the high tides; and as a proof that these rocks are not corroded by the ascending and descending tides, they are covered with *fucus* to the greateſt height attained by the salt water.

720. We landed at noon on the right bank, opposite to *Pill*, and ascended by an insensible slope to the village of *Shirehampton*, whence we discovered an extensive tract of *new lands* formed along the coast, through which the *Avon* has prolonged its course. Of these, all the parts fit for good meadows have been embanked; but there remains on the outer side a great extent of *forelands*, as they are called on the coasts of *Holstein* and *Sleswigh*, which are still sometimes overflowed by the spring-tides; however they afford pasturage in the summer, as is the case on all similar coasts. On the northern side, the em-

bankment begins immediately below *Shirehampton;* we there ascended it; and we proceeded on it for six miles, to the point where it is interrupted, and where the *New Passage* to *Wales,* across the great *æstuary* of the *Severn,* is situated.

721. As we walked on this dike, we observed, in many parts, that the level of the meadows within it was lower than that of the *forelands.* This is frequently the case, when new grounds are enclosed, if their soil has been formed on a sandy slope; for they have a disposition to *slide* down under the water of the sea (§. 472): and when thus reduced below its level, they are prevented, by the embankment, from receiving the fresh deposits of the tides, while these continue to accumulate on the *forelands.* On this account, it has often been necessary in *Holland* to raise the dikes, which have sunk with the *marsch* soil; the latter being, in some places, fifteen feet lower than the level of low water.

722. The breadth of this arm of the sea diminishing towards the *New Passage,* the waves have at last brought up *gravel* against the *forelands.* It is not from the coast itself that the *gravel* thus collected along it proceeds; for we have seen that its *strata* are of lime-stone, while this gravel is composed of rounded fragments of slate and quartz, mixed with small silices: it must then have lain on the *bed* of the *sea* at the birth of the *continents;* and in the sequel of these travels will be seen many characteristic signs

of the formation of that *bed* by the *subsidence* of the *strata*. Farther to the northward, the *gravel* becomes so abundant, that it has set bounds to the extension of the *forelands*, and formed a border to the meadows near the *New Passage*, where it has been necessary to continue the embankment by a wall; because, when the sea is high, the waves come up to its foot.

723. The interruption of the *new lands* at this spot is produced by a brook, arriving here to discharge itself into the sea. An immense *beach* having been formed here, composed of the *gravel* which I have mentioned, the brook has preserved through this its course; and an access having been thus opened to the waves, they have hollowed out a deep creek, into which the tides enter. In a small port formed by this creek are kept the vessels intended for the passage to the Welch coast; and they again arrive here on their return. The passage-house stands on this beach; we reached it at four o'clock; and wearied with our walk along the embankment, which the wind had rendered very disagreeable, we did not feel ourselves disposed to go any farther that evening. From the top of the house, we could see another embankment beginning at some distance, to the north of the passage, and enclosing another tract of *new lands*, with *forelands* on the outer side.—I do not think it necessary formally to oppose these observations to the hypothesis that the *sea* destroys our *continents*, and transports their materials to the *low-*

est depths of the ocean; an hypothesis which is one of the fundamental parts of the Huttonian theory.

June 18*th*. We left the *New Passage* at half past seven in the morning to return to *Clifton* through the interior part of the country. After having passed the beach, we entered the *marsh* which we had followed the day before by the sea-side, in order to cross it towards *Compton*, distant four and a half miles, here the breadth of the *marsh*. For some way we saw in this enclosed land a great deal of the small gravel of the coast; but it disappeared by degrees, and we found only the soil of the *marsh* itself, composed of sea-sand and the sediments of land-waters. This wide tract of meadows is called *Marsh common*, and very much resembles *Eyderstede* on the coast of *Sleswigh*; being, like that, covered with cattle: there was water in all the drains communicating with the sluices of the dike; which shews them to be below the level of the ebb-tides; for the weather was fine, so that this was not accidental water. The *marsh* is perfectly horizontal to the *original border* of this coast, where *Compton* stands: and as we ascended from that village, we saw, in places where the ground had been cut to make the road, that the soil consisted of that kind of foliated sandy marl, of a reddish colour interspersed with blue spots, which is found in various parts of *England* and of the continent. When we had gained a certain height, we had a view of the whole extent of the *marshes*, a tract more than eight miles in length, from the mouth of the *Avon* to the

Old Passage on the north, where a branch of a hill comes quite down to the sea. It was easy to judge whence these *new lands* had acquired such a breadth and extent; for the wind being high, the water of the sea was turbid the whole way across to the opposite coast of *Monmouthshire*; the tide also was low, and a sand-bank of great extent was uncovered. It is for this reason, therefore, that the tides and the waves carry to the shores so great a quantity of materials.

724. This is the *western* coast of *England*; and the phenomena which I have just described, and which will be seen to extend themselves along the whole coast of *Somersetshire*, are the same as those on the *eastern* side of the island; where, to explain what is observed on the coasts of *Suffolk* and *Lincolnshire*, Mr. Playfair, as has been seen at the beginning of this volume, has supposed *partial elevations*; thinking thus to efface on some coasts, that kind of *chronometer*, which, however, exists around the whole of our continents.

725. We arrived at 9 o'clock at the Black Horse public house, on *Crib's causeway*, extending across a *marsh*; and thence, after passing over a hill, we descended towards *Westbury*, into a vale, through which the small river *Trim* flows to the *Avon*. We observed along the road some *blocks* of a hard *limestone*, certainly not belonging to the external *strata* of the hill; for the latter, which dip almost vertically

inwards, (their section forming the surface,) are of a soft *lime-stone*, easily divisible into laminæ. But before we came down to Westbury, we had a view of the country extending westward to the coast, beautifully interspersed with hills, some of them insulated, with handsome houses surrounded by parks on their summits; their slopes, and the vales between them exhibiting a variety of culture; and the waters collected in the latter passing through them down to the *marshes*.

726. From *Westbury* we had a long ascent before we reached the top of the hills near *Clifton*, where great symptoms are seen of the catastrophes which have given to our continents, in many of their parts, this form of *hills* and *vales*. A number of large *combes* descend towards the course of the *Avon*, intersecting the rocks on its borders; while the cause of their formation is manifestly shewn by the state of the *stony strata* in the mass of the hill: the upper surface of this has no covering but the turf, because it consists of the section of the *strata* dipping inwards, with here and there some high parts forming rocks which rise above the grass. I saw here also a phenomenon frequently found on eminences of this kind; it consists of cavities in the form of funnels, towards which run the rain-waters that fall on the surface; there being under them some more continuous intervals between the dipping *strata* down to the level of the vales, where those waters form springs. After having passed over the top of these hills, we turned

towards *Clifton*, where we arrived at 2 o'clock, and spent the rest of the day.

June 19*th*. After having spent the morning at *Bristol*, we set out for *Bath*, passing along the left bank of the *Avon*; and here will appear the same proof as has been shewn at the former place, that *vales* have not been produced by *rivers*. On this bank, we passed over some ridges of hills, separated by *combes*; and from their highest parts we had a view of the large vale in which flows the *Avon*, either winding through meadows, or following the intervals between ridges of small hills longitudinally intersecting the vale; the declivity of the latter being so small, that in an extent of twelve miles, a few locks are sufficient to render the course of the river horizontal; so that, in common seasons barges can pass between *Bristol* and *Bath* with very little water.

727. This circumstance alone would render it improbable that the *Avon* had excavated such a *vale*, of which it has, on the contrary, elevated the bottom by its sediments during floods; but there are immediate proofs that this *cavity* is *original*, and has been produced by *subsidence*, not only from the situations of the *strata* on its borders, but from the difference, in that respect, between the opposite sides. In passing over the hills on the left bank, we saw, near *Bristol*, the sections of *strata* of a yellowish *limestone*, containing large *cornua Ammonis*. But long before we came to the bridge across the river some

miles below *Bath*, we saw the hills on this same side, sloping gently down to its border, their base discovering *strata* of what, in this part of the country, is called *Blue Lyas*, which, as well as the *red strata* mentioned before, extend through *Somersetshire* and *Devonshire*. The *lyas* is a *lime-stone*, commonly bluish, but sometimes grey; its grain is very fine, and it is disposed in very regular *strata*, from two to seven inches in thickness, some of which have on their surface a multitude of small shells of various species, mostly bivalves.

728. Another essential circumstance belonging to this left bank of the river is that on its declivity lies a *bed of coal*, bearing, like that of *Kingswood*, the impression of the catastrophes of all the *strata*; and the following particulars had been communicated to me by the colliers in a former excursion. The appearance of the surface is very far from shewing the position of this *bed*; for while, near *Bristol*, it is found at very little depth, it becomes lower as it approaches *Bath*; so that, in the space between the two turnpikes on the road, it is already fifty fathom beneath the surface, and near *Bath* it lies as low as eighty fathom: it has also the same fractures, and unequal partial subsidences, which are observed in *strata* of every kind, when it becomes an object of interest to follow them into the interior parts of the soil.

729. Now this *bed of coal* is entirely missing on the right bank of the *river*; and besides, when we

quitted the *blue lyas* at the foot of the gently sloping hills of the left bank, and crossed over by the bridge to the other side, we there found a hill with a rapid ascent, composed of strata of yellowish *lime-stone*, whence a promontory advances a great way into the vale below the bridge, the river flowing round its foot; and in one of its strata, imperfectly consolidated, we observed a quantity of large *cornua Ammonis*, which, on the left side, are found only near *Bristol*, and at a lower level. When the opposite banks of a number of *rivers* shall have been examined with a view to a similar comparison, it will be no longer possible to retain the persuasion that *streams* have *excavated* the *vales* through which they flow. This will continue to appear in the following excursion along the banks of this same river, farther up.

June 21*st*. We set out from *Bath* at eleven o'clock, still on foot, with the intention of observing the course of the *Avon* above that town, where it flows between hills nearer to each other than the preceding were.

730. In coming out of *Bath*, we crossed the river by the *new bridge*. On a former occasion, I had seen the ground lying between this and the foot of the hills, which is at present occupied by *Great Pulteney street*; it is an alluvial soil, formed by the river and some brooks. When we reached the hills, we proceeded along their foot, ascending the course of the river, till we came below the *Shum Castle*,

erected as an object for the embellishment of the prospect, but serving as a gate to an enclosed plantation. We ascended thither, going strait up the hill, though its aclivity is very rapid, in order to observe the situation of the *strata*; and at various heights on the slope we found their sections, produced by the *subsidence* of a part of their mass in the space in which at present the river flows. We afterwards continued to ascend, though less rapidly, and having crossed the wood, we came out on *Claverton down*.

731. It might suffice to have attentively surveyed this hill with its borders, and to have observed the appearance of the other hills around, to be convinced that *vales* are the effects of catastrophes; for the whole mass of this hill exhibits marks of them; its summit is covered with only turf, because it is formed of the *section* of lime-stone *strata* dipping inwards. We first went towards its brow looking down on the course of the *Avon* from *Warley* to *Batheaston*, from which latter place the river turns towards *Bath;* and we came to a part where we saw the hill abruptly cut down to a slope covered with wood. We descended on this slope by a fissure in the rocks, and saw it scattered with large masses of strata, partly buried under smaller fragments. Having reascended the hill, and proceeded on its border till we were opposite to *Wharley*, we found on its summit wide and deep clefts, forming separations between the masses

of the inclined *strata*; then proceeding southwards, we came to another part of its brow, where is a great section of the *strata*; and instead of finding a slope of rubbish at its foot, we saw there the nearest of the masses detached from it, forming, a little below, a wide terrace, to which we went down. Hence we had the view of a space bearing all the characters of a great *subsidence*: the slope of the terrace itself turned towards it is covered with large masses of the strata, though not attacked by any stream; and the whole space itself is interspersed with small hills, through an interval of which the *Avon* enters in its way down to *Warley*.

732. We returned hence towards *Bath* along the left bank of the river; and we saw every where on the slope of the hills on this side, as well in the upper sections of the strata, as in the large masses scattered on the slopes, certain marks that the large *vale* had been formed by a *subsidence*. It is, at the same time, evident beyond all doubt, that the *river* cannot have had any share in the formation of this *vale*; for, besides that its common course occupies but a very small part of the bottom, which, in reality, it has raised by its sediments during floods, its declivity is so small, that, in order to bring a part of its water to a level of some height near *Bath*, it has been necessary to conduct it from a little below *Warley*, in a canal dug along the foot of the hills on the left bank, and prolonged at the same level through meadows formed on a great extent of alluvial ground

which lies between those hills and the natural course of the river. We did not proceed along the left bank any farther than *Warley*, because the river makes a very wide turn; and besides, I had observed that part in 1787. I had then, also, crossed *Claverton hill* by a different road; and as detailed examples of phenomena belonging to general classes fix the attention more than abstract definitions, especially when those phenomena may, as is the case here, have many observers, I will relate what at that time I saw.

733. I then ascended the hill from *Witcombe*, a village situated at the bottom of a *combe* leading up to *Prior Park*. In the lower part of this combe, the sides of which exhibit sections of the *strata*, I saw one *stratum* similar to that, described in § 694, at the top of *Lansdown hill*, consisting of concrete masses in calcareous sand, with marine bodies enclosed in them. I found here some of these concretions, in which the nucleus was a madrepora stellata. Above this, I saw the section of *strata* more completely petrified, inclined inward, and presenting their section towards the vale of the river. Lastly, on the top of the hill, I found the quarries whence is taken the *free stone* of which the houses in *Bath* are built: its grain is fine, but has little coherence: it is easily sawn when first taken out of the quarry, but becomes hard when exposed to the air; and its colour then changes from yellowish to grey. Many of the *Bath* houses have only a covering of this stone, which, for that purpose, is sawn into pieces

four or five inches in thickness. I entered several of these quarries, where I saw the *strata* inclined inwards; but this inclination differs in different quarries; a circumstance arising from the difference in the angular motions of the masses separated by the fractures.

734. After having passed *Claverton down House*, situated to the east, I found on the surface thin strata of *lime-stone*, the same as those on *Lansdown*, and under them thick strata, apparently of the same stone, very different from the *free-stone*, and containing a large quantity of small marine bodies. It is possible that the thin superficial strata may be only a part of these, foliated by the action of the air. At a lower level, in a direction towards the village of *Combe* the *free-stone* is found on the surface; which, though nearly horizontal, is the upper section of the *strata* inclined inwards, as I saw in some of the quarries. The hill is here cut down abruptly towards a *combe*, whence the village below derives its name; by this village passes a brook, which is composed of the waters of several *combes*, and flows into the *Avon*. In this part of the country, most of the brooks issuing from *combes* have the generic name of *Combe-brook*, with some distinctive epithet. The side of the above *combe* formed by *Claverton hill* exhibits the section of the *free-stone* strata which are here worked.

735. Having reached the river side, I followed it, on the same bank, as far as *Claverton house*; and in my way I found masses of the above mentioned concretions, and nuclei of the same stone moulded within large chamæ. I here crossed the *Avon* to *Warley*, whence I proceeded along its right bank. Many persons resort hither to view the *Warley rocks*; which exhibit a phenomenon common among great mountains, but rare among hills; whence it is an object of greater curiosity in this country, and at the same time more interesting, as its cause is more evidently seen. The hill rising on this side, named *Kingsdown*, has a slope of great extent towards *Warley*; it is ascended at first through woods, above which it is covered with immense masses of rocks, partly buried among smaller fragments. When this phenomenon is found on the slopes of the *Alps*, it is supposed, very naturally, though often erroneously, that these masses have fallen from some rock above, many rocks being seen in their neighbourhood; but here, no such supposition can be formed; for the upper part of the slope presents but a very small section of the *strata*; and such masses could not have detached themselves from it, unless a large *vacancy* had already existed in their front. Thus every thing in this spot indicates that a great *subsidence* must have taken place before it, and that these masses and the smaller fragments are parts which have been accumulated in a slope on its borders.

736. I ascended this slope towards the section of the *strata* and I followed it to the quarries above *Bathford*; where appears the section of many species of *strata*, and the *stratum* of *free-stone* is worked under that to which belong the *Warley rocks*. The latter, very distinct from the rest, is not found in the side of the opposite hills; at least I did not see it there: it consists of a kind of *lime-stone* which I have seen in the *Jura*, especially in the country of *Neufchatel*; it is full of holes, like those made by large worms in oak-timber, or by pholades in the rocks of some parts of the sea-shore. These holes, however, are found only in the sides which have been long exposed to the air; for in the quarries, where this stratum covers that of *free-stone*, none are seen in the parts recently broken; they are produced by the actions of the air on sections of the ramifications of a calcareous matter, which is not petrified; these are distinguishable by the difference of colour in the parts newly broken, where it is easy to form them into similar holes with any pointed instrument.

737. From these quarries I ascended the hill, by the side commanding on the N. E. the vale wherein flows *Catherine brook*, which is seen, to a great distance, winding through meadows. This is one of the most beautiful rural prospects in the neighbourhood of *Bath*, on account of the multitude of small hills, richly wooded, that slope down to the border of the meadows, and break their outline with a variety of inflections. It is impossible to believe

that

that this vast space can have been hollowed out by the small stream flowing in it; and its production by a great *subsidence* of the *strata* very manifestly appears, when, in descending towards it the rapid slope of *Kingsdown*, we find projecting rocks, which show *sections* of the *strata* of the hill, here seen to incline inwards. I came down this way to *Batheaston*, and crossing the river, I returned to *Bath* by a path through the fine meadows above mentioned, formed on an alluvial soil.

738. It would be too long to detail the particulars of all the observations which I have made in this part of the country; my chief view being to excite the attention of the many persons who ramble over it merely for amusement, and to direct their notice to an object so interesting as that of the features, characteristic of the cause of the production of *vales* between *hills*, which every where abound here. I shall therefore only relate another of my excursions, wherein, among new examples of phenomena common to every part of the neighbourhood of *Bath*, will appear one directly proving that the *catastrophes*, which produced all the disorder observed here in the *stony strata*, evidently formed on the bottom of the *sea*, took place during the time when those *strata* were still covered by its waters.

739. I went out of *Bath* by the old bridge, and thence ascended *Hollow-way*, a road cut on the foot of a hill sloping rapidly down to the river. In this

slope appear sections of the same *calcareous strata* incompletely petrified, which, in *Bath* itself, form the steep declivity below *Belvidere* in the parish of *Walcot*. Above *Hollow-way*, I continued to ascend towards a part of the hill formerly called *Greenway farm*, where, since *Bath* has extended itself over all the surrounding hills, the row called *South-hill houses* has been built. Beyond this, I passed on a bridge the upper part of a *combe* in which a brook is formed. This *combe* is here very narrow; but it grows much wider, in proportion as it becomes deeper, and at the bottom it joins several other *combes* arriving laterally, whence also brooks proceed.

740. Continuing to ascend by the same road, when I had reached the top of the hill, I saw on the left an eminence called *Antony hill*, where some very curious quarries have been opened on the *section* of the *strata* at the top of the slope the lower part of which forms one of the sides of the above mentioned *combe*. In this spot has been long worked a species of *lime-stone strata*, naturally separating into flags, four or five inches in thickness; their size being limited only by the cracks across the stratum. The working of these strata has carried backward the summit of the hill; and it thus presents an abrupt side, rising above a terrace composed of rubbish. In the upper part of this section, are seen *lime-stone strata* the separations of which form lines nearly horizontal; and they are covered with a very thick loose soil, consisting of sand and fragments of lime-stone. It

is not, however, for these *strata* that the quarry is worked; on the contrary, they have, in this part, nearly stopped the working, there being so much difficulty in removing them and clearing away the loose soil: those which constitute the principal object are under them; and, instead of being *horizontal* like the former, are very considerably *inclined*, though sensibly of the same nature with respect to their substance. These inclined *strata* have been followed a great way under the others, pillars being left to support them; and thus have been formed some very picturesque grottoes, lined with mosses and ferns; but the quarry is now almost abandoned, probably from the apprehension lest the vault, which is much cracked, should suddenly fall in upon the workmen.

741. This will lead me to a very important geological consideration concerning the Huttonian theory; it being essential to determine, whether, as that theory supposes, the *fractures* and *dislocations* observed in our *strata* have been the effect of an *elevation* which has produced our *continents*; or whether, according to my system, all these catastrophes had taken place on the bottom of the sea, before the birth of those continents.

742. A phenomenon of the same nature as that observed at *Antony hill* is found also in some mountains, but with this difference; that the *inclined*, nay, almost vertical strata, which commonly are of

schistus, are covered with strata nearly *horizontal* of a quite different nature: in the examples cited in *Scotland* by Dr. Hutton and Mr. Playfair, these upper strata are of *sand-stone*; in others which I have seen in the *Hartz* and at *Freyberg*, they are of *lime-stone*. The upper *strata*, as well as the lower, must have been formed in the sea; now, as in the Huttonian theory, the latter are supposed to have been broken in the very act of *elevation* which brought them above its level, this circumstance has of necessity led to the strange hypothesis already refuted under different forms; namely, that subsequently to the production of our *continents* by *elevation*, some of their parts, by *subsidence*, returned below the level of the *sea*, where new *strata* were formed upon them; after which they were again *elevated*.

743. This is an auxiliary hypothesis in a theory attacked on all sides by facts; it may however preserve some appearance of probability, as long as it relates to *strata* so different from each other as those of *schistus*, and *sand-stone* or *lime-stone*; because, these differences implying different states in the sea, it may be supposed that one of those states preceded, and the other followed, the *elevation* of the continent, and the *subsidence* of some of its parts. But in *Antony hill*, the *strata* subverted, and those formed upon them, are not only both *calcareous*, but both of that distinct species which was called *oolite* by ancient naturalists, because they supposed

it to consist of petrified eggs of fishes. Thus this same state, well characterized, of precipitations in the sea, before and after the catastrophe which produced the *subversion* of the inferior *strata*, evidently shows the whole of these effects to have taken place on the bottom of the sea itself, within a short period of time; and the following phenomena will farther evince that this first catastrophe was succeeded by greater, comprehending the same *strata*, together with those which lay beneath them.

744. Before I proceed to these new monuments of catastrophes, I must point out a difference between the phenomenon of *Antony hill*, and those of the places where new *strata* have been formed on overthrown *schisti*. In the latter case, the upper section of the *schisti* is commonly irregular, and the first of the succeeding *strata* has been moulded on their asperities; while in *Antony hill*, the summit of the inclined *strata* forms a strait plane, whereon the horizontal strata rest. This phenomenon appears to belong to a particular species of *lime-stone*, which is disposed, like the *columnar basalts*, to divide itself by strait planes across other kinds of divisions; as is seen also in certain species of *slate*. My nephew observed at *Slane* in *Ireland*, twenty-four miles to the north of *Dublin*, the same phenomenon as this of the lower *strata* in *Antony hill*; namely, an absolutely plane surface, (there not covered by any other *stratum*,) produced by the section of *lime-stone*

strata inclined inwards, forming with that surface an angle of about 40°.

745. I proceed to the monuments observed in the vicinity of *Antony hill*, of catastrophes posterior to the period when the above *horizontal* strata were formed on those which had already undergone an *angular* movement. It not having been thought prudent to work this quarry any farther, the quarry-men have laterally followed the brow of the hill; and there, clearing away the loose soil of the slope, they have found the section of the same *strata*, where those which are inclined are still found under the horizontal; nor is there any occasion to follow them far within, because, by continuing to clear away laterally, the same section is still found. Now here already appear the effects of new catastrophes; for these *strata* frequently change their level by fractures, in which all is in disorder, and which, as will be seen, pass quite through the hill.

746. But the most evident symptoms are on the slope, where is seen very clearly in what manner was produced the cavity at present constituting the *combe*, of which *Antony hill* forms the highest side. I began to descend by this slope, and found it to be composed of terraces one below another, each of them having above it the section of those masses of strata wherewith, previously to its subsidence, its own mass had been united. Within a certain space, I was able to descend, from terrace to terrace, by

crevices in the abrupt sections; but at last I came to one which was very high, and in which, though I had a great extent of it within my view, I could not perceive any part where it was possible to descend; so that, not knowing how far I might be obliged to proceed on it in a direction leading me away from the high road, before I should find a way down to the lower terrace, I thought it best to reascend to the road, and to cross to the other side of the *combe*, that being lower and less intersected, and commanding a view of this whole side of *Antony hill.* Having then repassed the bridge I turned, on the right, into a cross road with which I was well acquainted, called *Greenway Lane*, passing along the upper part of the slope: thence I entered a field fronting the side of *Antony hill.* It would be difficult to find any geological monument more agreeable to the view. The side of the combe opposite to it is wholly composed of large terraces, where the finest vegetation, in fields scattered with trees and divided by hedges, spreads a cheerful veil over that scene of catastrophes; but the experienced eye may easily retrace them, in the abrupt sections of the strata above the terraces, and in the interruptions of the latter, by the continuation of the fractures described in the quarries above; occasioning the terraces themselves to descend also in steps towards the lower part of this *combe*, where it joins another, one of the sides of which is formed by the same hill.

747. I shall not proceed any farther in describing the neighbourhood of *Bath*; what I have said may, I think,

I think, suffice to engage those who resort thither from all quarters, in the water-drinking seasons, to examine, in their walks and rides, the interesting phenomena which that whole country exhibits; and when they shall have gained a little experience in this study, they will, I doubt not, be convinced, that, if even an incalculable *antiquity* were ascribed to our continents, it would be in vain; for on themselves can be found no cause of the dissection of their surface into *hills*, *vales*, and *combes*, the real cause of these forms having evidently been catastrophes anterior to their *birth*; and from the real effects produced on them, the era of that event cannot be removed to the distance of a very great number of centuries. A conclusion so important, that it must not be thought strange if I frequently return to it in other places.

FIRST JOURNEY INTO DEVONSHIRE.

748. This is a country, in which, as well as in *Dorsetshire,* I have made several journeys, at different times, and in various directions. However, I shall preserve the form of a journal, as it possesses many advantages for the reader, no less than for the writer. It is true that thus the determination of many of the objects observed in one journey occurs only in another, anterior or subsequent in its date; and this is, in some measure, a defect; but it is more than compensated by avoiding that which would be produced by collecting together all the observations of the same objects made in different journeys; since those objects would then respectively be insulated, and deprived of the geological connections subsisting, in nature, between them and others in their neighbourhood.

749. We enter here into the field of Mr. Playfair's observations, whence he has taken his examples of the manner in which rivers have cut their way to the sea. I have already introduced his system in this respect, because I have had occasion to compare it with the phenomena of the same coast, from *Hampshire* hither. However, as we are approaching the places which he gives as examples, I will now

cite the whole passage, as it stands in the XVIth of his Illustrative *Notes*, beginning p. 368.

" The *mouths* by which *rivers* on bold rocky " coasts discharge their waters into the sea, afford a " very striking confirmation of the conclusions con- " cerning the general system of *waste* and *degrada-* " *tion* which have been drawn above. At these " *mouths* we usually see, not only the bed of the " *river*, but frequently a considerable *valley*, cut " out of the solid rock, while that rock preserves its " elevation, and its precipitous aspect, wherever it " is not intersected by a run of water. No con- " vulsion that can have torn asunder the rocks; no " breach that can have been made in them, antece- " dent to the running of the waters, will account " for the circumstance of every *river* finding a cor- " responding *opening* by which it makes its way to " the sea; for that *opening* being so nearly *propor-* " *tional* to the magnitude of the river, and for such " breaches never occurring but where streams of " water are found.

" The actual survey of any bold and rocky coast, " will make this clearer than any general statement " can possibly do. Let us take, for an example, " the coast of the British Channel, from *Torbay* to " the *Land's End*, which is faced by a continued " rampart of high cliffs, formed of much indurated " and primeval rock. If we consider the breaches " in this rampart, at the *mouths* of the *Dart*, of the

" *Plym* and *Tamer*, of the river at *Fowey*, of the " *Fal*, the *Hel*, &c. it will appear perfectly clear, that " they have been produced by their respective *streams*. " Where there is no stream, there is no breach " in the rock, no softening in the bold and stern aspect which this shore every where presents to the " ocean. If we look at the smaller streams, we find " them working their way through the cliffs at the " present moment; and we see the *steps* by which " the larger *valleys* of the *Dart* and the *Tamer* " have been cut down to the level of the sea. If " we would have still clearer evidence, that no " breaches made antecedently to the running of the " rivers have opened a way for them, we need only " look to the opposite side, or northern shore, of " the same promontory, where we also find a series " of outlets, all originating in the ridge of the " country, and becoming deeper as they approach " the sea, but altogether unconnected with the openings on the south side; and this could hardly have " been the ease, had they been the effects of previous concussions, or of any peculiarity in the " original structure of the rocks.

" In contemplating such coasts as these, when " we go back to the time *when the rivers ran upon* " *a level as high as the highest of the cliffs on the sea-* " *shore*, we *must suppose*, that the land then extended " many miles farther into what is now occupied by " the sea. When at *Plymouth*, for instance, the " *Tamer* and the *Plym* flowed on the level of *Mount*

“ *Edgecombe* or of *Staten Heights*, if the rivers
“ ran with a moderate declivity into the sea, the
“ coast must have advanced many miles beyond the
“ present line. Thus the land, when higher, was
“ also more extended, and the limits of our island
“ in that ancient state, were doubtless very dif-
“ ferent from these by which it is at present circum-
“ scribed.

“ If with the same views we consider any other
“ of the bold coasts which the map of the world
“ presents us with, we shall quickly remark, that
“ wherever a deep intersection of the sea is made
“ into the land, as on the western shores of our own
“ island, or on those of *Norway*, a river runs in at
“ the head of it, and points out by what means such
“ *inlets* are formed, viz. by the *united powers* of the
“ *sea* and of the *land*, the waters of the latter
“ having opened the way by which those of the
“ former have penetrated so far into the country.
“ It is not meant assuredly to deny the irregularities
“ of the sea-coast, as it may have originally existed;
“ these irregularities no doubt determined the initial
“ operations of that waste and decay, by which,
“ in process of time, they were themselves entirely
“ effaced.”

750. It may be easily seen, that, when terrestrial phenomena are considered in this point of view, the centuries that have elapsed since the commencement of the *present state* of our globe must be counted by thousands; for the only way in which it is attempted

in this theory to account for the fact, that no progress is seen in these excavations of *vallies* and enlargements of openings to the sea, is by assuming that this progress is too *insensible*, not only to be perceived during the *life* of a single *man*, but even to have any record of it transmitted from one *generation* to another: and to this is added, as the ground of the argument, that *time past* has no limit. But then at what epoch, in this immensity of time, are we to place the origin of the *human race* on these continents? It is by reference to this object, that these discussions are rendered so important; it is thus that they belong, not merely to natural history, which properly is interesting only to those who occupy themselves with its pursuits, but to the history of man, which interests the whole human race; therefore men are more nearly concerned in geological discussions, than many among them generally suppose.

751. It is fortunate that Mr. Playfair has named some of the places whereon he founds his ideas, and that he has defined what it is which he expects them to prove: according to him, we must there see with *conviction*,—" That no *convulsion* that can have " torn asunder the rocks, no *breach* that can have " been made in them, *antecedent* to the running of " the waters, will account for the circumstance of " every *river* finding a corresponding *opening*, by " which it makes its way to the sea; and for that " *opening*, being so nearly *proportional* to the magni- " tude of the river. That *rivers* have run upon " a level as *high* as the highest of the cliffs on the

" sea-shore; and that therefore we *must suppose*, " that the land then extended many miles farther " into what is now occupied by the sea." This, in Mr. Playfair's opinion, is what we ought clearly to perceive in studying this coast of *England*, especially from *Torbay* to the *Land's end;* and hence I was induced, (though persuaded by my own observations on other coasts that his ideas were wholly illusory) to visit all the *rivers* pointed out in his work, and to follow their course to the sea. Now all these rivers will be seen to concur with a great number of others, which I have already described, and shall describe elsewhere, in demonstrating—" That, from " the *origin* of our *continents*, the streams formed " by the land-waters have entered the same *channels*, and discharged themselves into the sea by the " same *openings*, through which we see them flow at " present:—That these *channels*, and the *openings* " themselves, were the effects of *convulsions* of " the *strata*, not only *antecedent* to the time when " these waters began to flow, but to the birth " of the continents:—That these waters, since " they have begun to flow, have raised their channels, " instead of deepening them:—And that the sea, " far from having encroached on the lands, has, on " the contrary, been almost every where removed " to a distance from them." All this had already been clearly evinced by my preceding observations; but it was become necessary to deduce the proof from the very *rivers* named by Mr. Playfair. The object will therefore now entirely change its aspect;

for

for when I shall have proved, from the places to which he has himself referred, that our *continents* are not of *great antiquity*, this circumstance will bring near to our own times the epoch when they first became the habitation of men.

752. I could not have undertaken these travels under more favourable auspices. My ancient and respectable friend Dr. Fisher, then Bishop of *Exeter*, and now of *Salisbury*, besides a general letter of recommendation to all the clergy of the former diocese, which includes *Devonshire* and *Cornwall*, was so good as to give me others for his particular friends; and Mr. Nott, who was employed under him in the education of the Princess Charlotte of Wales, did me the same favour. It will be seen, in the course of my travels, how much this assistance contributed to the extension and exactness of my observations.

753. I began my first journey in *Devonshire* in September, 1805; and Lady Rolle, whom I had met at *Weymouth*, having given me an invitation to *Bicton*, a seat of Lord Rolle's, where he commonly resides, I accepted it the more gladly, on account of the vicinity of that place to many of the objects which I had in view.

Sept. 28th. 1805. I set out from *Weymouth* at ten in the morning, and took the road already described through *Dorchester*, *Bridport* and *Charmouth*. At the latter place, I ascended the interior slope of the ridge

of

of hills described in a former journey, bordering the sea as far as *Lyme;* but, at the extremity of this ridge, instead of going down to *Lyme*, I crossed the hills behind which stands the town of *Axminster*, so called from the small river *Ax*, flowing by it through meadows. I shall stop here to describe the course of the *Ax*, because, in another journey, I followed it down to *Axmouth*, where it discharges itself into the sea. I shall then have occasion also to describe the road from *Axminster* to *Exeter*, at which city I arrived the same evening.

Sept. 29*th*. I spent the morning in forming a general idea of the situation of this city, which by its connexions, on one side with the sea at *Exmouth*, and, on the other, with the vallies farther inland, has occupied me in several journeys; because the *Ex*, though not named by Mr. Playfair, is, in a geological point of view, one of the principal rivers of this coast; and it will offer the first great example of what I have announced in the above propositions.

754. *Exeter* is a handsome manufacturing and commercial town; as, though in an inland situation, eleven miles above *Exmouth*, it is still properly a sea-port. According to Mr. Playfair's system, the space through which the waters of the *Ex* flow from hence to the sea should have been hollowed out by that river; as well as the similar spaces, from *Totness* to *Dartmouth*, from *New-bridge* to *Plymouth*, from *Truro* to *Falmouth*, ascribed by him to the *Dart*, the

Plym and the *Fal*; together with many others of the same nature, which I shall describe, and which all possess this common character, that the tides ascend in them up to the point where their respective rivers arrive at the level of the sea: but here already it will be seen, that these spaces were originally gulphs, and that the rivers have entered their heads ever since they at first began to flow.

755. From the upper part of the city, I went, by streets descending very rapidly, down to the port, to which large vessels still come up, though now only by artificial means; for the sediments of the river, and the sand brought in by the tides, (previously to a change which I shall mention,) have filled up so great a part of the gulph, that, in order to preserve the water at a proper depth near the quay of the city, it has been necessasy to keep its level raised by means of a *dam*, with a lock for the passage of vessels. Dams of this kind, of which there are many for the same purpose at the head of other æstuaries on this coast, are called *Wears*. The tides still rise up to this *wear*, but their height has not exceeded two feet, since the above mentioned change at the entrance of the gulph; this change has been produced by the formation of an immense *bank*, which I shall describe in the course of this journey, and which, leaving only a passage for vessels, renders that of the tides so narrow, that they have not time, before the ebb, to rise, at the head of the gulph, to any greater height. The lock of the *wear* is opened,

from time to time when the river is much swelled, in order that, by the rapidity of its current, it may carry away the deposites made by the tides in the channel still preserved between the *new lands*, and thus keep it at a sufficient depth for the passage of vessels.

756. The hill whereon *Exeter* is built formed originally a long promontory in the gulph; but it now no longer appears such, because *new lands*, covered with meadows, extend themselves on both sides nearly to its extremity, on which stands the town of *Topsham*, where there is a port more conveniently situated than that of *Exeter* for the country carriage of many articles of great bulk and small value. Here, for example, arrive coals from *Newcastle*, for the consumption of a great part of the country; and likewise another kind of coal from *Wales*, called *culm*, which is not proper to be burnt in grates, but is used in lime-kilns: this comes to *Topsham*, because *lime-stone* is also brought here from the quarries at *Plymouth*, and is burnt with it; the *lime* being afterwards carried into the neighbouring country, and used in dressing the lands, as the *chalk* is in *Dorsetshire*.

757. The hill, thus extending from *Exeter* to *Topsham*, consists of the same *red strata* which I have described near *Bristol*, and which I must here more particularly define, because they will become in the sequel a great object of attention, as well in *Somersetshire*, as in *Devonshire*, and part of *Cornwall*.

wall. These *strata* are composed, in part, of loose *sand*, mixed with reddish clay, sometimes indeed quite red. In certain places, as in this hill at *Exeter*, some of these *strata* contain a great quantity of small fragments of *schistus;* in other parts, those fragments are much larger; they are, besides, sometimes angular, and sometimes rounded. These *soft strata* are almost everywhere intermixed with others which are *indurated;* and indeed, in many places, they are all in the latter state. In some parts, the fragments of extraneous stones contained in the *red strata* are of *grey wacke*, which often accompany the *schisti;* and elsewhere these fragments are intermixed with others of *lime-stone.* Lastly, these *red strata* are in some places associated with *strata* of *lime-stone*, in some, with those of *schistus*, and in others, with *sandy strata* of a quite different species: now all these different strata have undergone such catastrophes as form a real subject of astonishment. In travelling through the country, I often lost sight of the *red strata*, but I met with them again, sometimes in certain associations with others, which indicated their respective original positions; while elsewhere the different species formed distinct ridges; till at length I came to a tract where the hills, thus strangely mixed, were overspread with large blocks of *granite.* In a word, there are few countries which more clearly manifest the *successive* catastrophes undergone by all our strata, while yet on the bottom of the *ancient sea*, that is to say, before the birth of our *continents.* I have thought it proper to give at first a general a general idea of the geological aspect of the country, in order to fix the attention of my readers on this latter consequence of the phenomena observed here: I shall seldom repeat it in the sequel, but shall confine myself principally to descriptions.

758. Having followed the left bank of the *Ex* beyond the *wear*, I crossed the river in a boat, in order to observe its right bank: this forms a plain, little raised above the level of the sea, and extending to the foot of more or less distant hills; and here the *red soil* still prevails. The creeks on this side, as well as a large space in this part of the gulph, are now converted into meadows, formed on the sediments of the land-waters and of the tides. I re ascended the course of the river on this side, and thus reached a part of the suburbs of *Exeter*, which I shall describe in a future excursion. I then repassed the river on a handsome bridge, which rises to meet the lower end of the great street proceeding hence to the upper part of the city.

759. I contented myself for the present with this first view of the country near *Exeter*, because, according to my plan, I was to return hither by different roads; and it was particularly my intention to make some stay here, when the Bishop should be at the palace, for the purpose of extending my survey farther with proper directions. I therefore set out in a chaise from *Exeter* at one o'clock, for *Bicton*, that place being eleven miles distant, and situated

near the *Otter*, which is the first river to the eastward of the *Ex*, and is followed by the *Sid*, the next that I intended to observe.

760. My road, as far as *Bishop's Clyst*, passed over hills of the *red soil;* and in several excavations made to lessen the declivities, I saw that though, in many of the *strata*, fragments of *schistus* were intermixed, there were others parallel to them which contained none. At *Bishop's Clyst* begin the meadows formed on the *new lands*, filling up a great part of the ancient gulph to the east of the promontory of *Topsham*. The small river *Clyst* first winds through these meadows, and then, flowing along by the promontory, there enters the gulph, in the part still remaining free. This whole extent of meadows is intersected with drains, to carry off the rain-waters, and those of some perennial rivulets. If this spacious *marsh* did not lie within a gulph, of which the opening to the sea is so much closed, that the waves have there no perceptible action, it must have been enclosed with dikes, like the *marshes* of *Sleswigh* and *Holstein;* but the tides in it rising only two feet, and there being no large waves, it is circumstanced like those on the coasts of the *Baltic;* having been so much raised by the deposits of the waters, that it can be inundated only by the highest spring-tides, combined with land-floods; and of these the effect is but to raise and extend it by their sediments.

761. Near *Woodbury*, I began to ascend the ridge of hills separating the vale of the *Ex* from that of the *Otter*. This part of the country will present another example of the differences found in the nature of the *hills* and the *gravel* which covers them, on the opposite sides of the same *vallies;* but I shall not enter into particulars respecting this till my return from *Sidmouth*, confining myself here to the description of the above ridge of hills. I first passed, at its foot, over some low hills consisting of the *red strata*, like those on the western side of this vale of the *Ex;* but on reaching the high ridge, I found its mass composed of *soft strata*, mostly *grey*, of different natures, and its surface covered with fragments of the stone called *grey wacke* by German mineralogists, from whom those of most other countries have adopted the same denomination; I have already said that its *strata* are often intermixed with those of the *schisti*. Descending afterwards on the other side, towards the vale of the *Otter*, I found, near the bottom, a similar border of small hills of the *red strata*, which are very fertile: among these is situated *Bicton*, where I arrived at half past three. Lord Rolle was then at another of his estates, in the N. W. of *Devonshire;* but Lady Rolle received me very obligingly, and assisted me in my views. I spent that evening and the following morning in visiting the immediate neighbourhood of *Bicton;* which, being on the confines of *strata* of different natures, presents, like all similar places, interesting details; but in journeys like the present, it would take up too much time if I did

not confine my descriptions to the great features of the country. My plan at this time was to proceed eastward as far as *Sidmouth;* and Lady Rolle was so good as to send me there in her own carriage, with a servant to answer such enquiries as I might wish to make.

Sept. 30th. From *Bicton* I descended into the vale of the small river *Otter*, the course of which towards the sea became, in another journey, one of the objects of my observation: at present I only crossed it to *Otterton,* situated on the foot of the opposite hill belonging to the ridge whereby this vale is separated from that of the *Sid.* This chain of hills is much divided, its first interruption being a large *combe,* which terminates towards the sea in cliffs, forming a semi-circle, or kind of bay.

762. These cliffs are a section of the *red strata;* and following their brow, we came to a part, below which, my guide told me there was, on the sea-shore, a very curious grotto, called *Larderum cove:* I quitted the carriage, and he led me down a very steep path formed on the side of a cleft by which the waters of the combe run off, but which, at that time was dry: When I reached the sea-shore, I found there indeed an object extremely picturesque, large pyramids of the *red strata* encompassing a small cove with a high beach in its front, on which we descended. This being the middle of the bay, it is the point where the greatest quantity of gravel is accumulated by the waves;

waves: I learnt from my guide that it is almost always accessible; and that, when the tide is out, it is possible to walk all round the bay, where the cliffs are everywhere very curious; but as it was then high water, I could not go beyond this point.

763. All the *cliffs* formed of these *red strata* are in some measure interesting, as I shall have occasion to point out, not only from the various degrees of *induration* of the several *strata*, but from the differences in that respect between different parts of the same *stratum*, which resist more or less the impressions of the air; and the hardest parts, remaining thus in relief, assume all kinds of grotesque figures. But, besides all these causes of the remarkable appearance of the *red cliffs*, they have one in common with all others which are composed of *stony strata;* namely, the different situations and ruptures of those *strata*, resulting from their ancient catastrophes. I had many opportunities of observing the forms of these, by passing along the brow of the cliffs; and I saw several little coves like the former, with small capes projecting on their sides; one of these capes is hollowed into an arch, which may be passed under at low water; and in many places, large masses of the same strata appear in the sea, in the front of the capes.

764. The circumference of this bay and of its cliffs being the section of a *combe*, as the road ascended one of the sides of the latter, the cliffs became higher, and I then saw the *red strata* disappear; these are at

first covered with a very thick loose soil; and the summit of the hill consists of a grey sand, mixed with large masses of a particular kind of *flint*, which presented me with the first example of a phenomenon hereafter to become an important object in the course of my travels in this county; for these *flints* are of the same nature with those on the *Blackdown hills*, whence Mr. Playfair has been led to an hypothesis, the examination of which will occupy me for some time, because it is connected with a point of great importance in Geology. There is here a prodigious abundance of these *flints*, not only loose on the surface, but forming beneath large masses of *pudding-stone*, in which they are all in contact with each other, and the small quantity of sand between them has been consolidated into a very hard substance.

765. From this spot descends a narrow *combe* in the same direction with the coast, terminating among the low hills on the side of the river *Sid*, and leaving but a narrow ridge on the brow of the cliff, along which the road passes. This is one of *combes* parallel to the coasts, that evidently cannot have been excavated by the waters, the upper part having too little extent to have ever permitted these to form a stream. Here the cliffs rise very much; and I came to a spot where a signal-post stands, whence there is an extensive view along the coast, and up the vale of the *Sid*. Beyond this, I saw, on the eastern side of the river, several ridges of hills, terminating in cliffs towards the sea: the two first of these cliffs consist of the *red strata*;

but those which follow are absolutely different, being composed of a white *lime-stone*, nearly resembling *chalk*; of these I shall give some details in a future journey.

766. From the signal hill, I descended, by a very winding road, into the vale of *Sidmouth*, the opening of which towards the sea is about a quarter of a mile in breadth. I had a recommendation from the Bishop to Mr. JENKINS, the clergyman of the parish, who lived on an estate of his own, on the hill to the east of the town. When I went thither to call on him, he gave me an obliging reception, and accompanied me to the places which I wished to observe; so that it is from his information that I am going to give a general idea of this very beautiful vale, equally picturesque and rural in its aspect.

767. From the side of the hill where Mr. Jenkins's house stands, the vale is seen to terminate in a fine amphitheatre of hills, where the parts not in tillage are covered with grass fields, most agreeably interspersed with woods. Had I been alone when I viewed this upper extremity of the vale, I should have been at a loss to guess in what part the *Sid* entered it; but Mr. Jenkins pointed out to me a lateral interval in the hills; and through this, as he informed me, the river arrives from a vale above, covered with meadows, in which it meanders, and which it inundates in very rainy seasons. From this point, the stream flows between the foot of the hill on the east, and a row of hillocks occupying a part of

the vale; and the town of *Sidmouth* is built on the mount nearest to the sea. The rest of this interval consists of meadows, in which the river continues to wind down to it mouth, and from the spot where we stood, this mouth is as little visible as its entrance into the vale; because a very wide *beach*, whithout any perceptible opening, extends from one cape to the other, along the upper part of a strand, very convenient for sea-bathing.

768. Mr. Jenkins was so good as to lead me to the extremity of the eastern cape, which is formed by the low hills with *red strata*, bordering the higher hills of a different nature, and also terminating in cliffs towards the sea. Here I saw these *red strata*, of which the section shows itself on the side of the vale, pass under those of the great hill. At the extremity of the cape may be seen what the *river* is, which here issues from a *wide* vale to the sea, and gives its name to the town of *Sidmouth*; it being so *small*, that, in turning round the cape, it loses itself in the gravel. It is only after long rains and the melting of snows, that the *Sid* acquires sufficient volume and rapidity to cut through the beach, and flow in sight; and then the level of the interior inundation is determined by that of the tides; in the high spring tides it rises within the beach up to the bottom of the town; and this proves that there was here an *original gulph*, which has been separated from the sea by the formation of the *beach*. When the inundation has subsided, the waves soon close the breach, by bringing

back the gravel carried away by the stream, which, reduced to the usual size, again filters through it. This is a new proof of my assertion, that facts are absolutely contrary to the idea formed by Mr. Playfair of the course of rivers to the sea, and likewise to his opinion that the size of their mouth is nearly proportional to their volume; a circumstance scarcely any where occuring, and merely accidental wherever it is found; as will be farther seen in the sequel.

769. I set out in a chaise at four o'clock, for *Exmouth*, at the distance of nine or ten miles from *Sidmouth*; and it was on this road that I principally observed the phenomenon to which I have above alluded, of the difference of the *gravel* on the *hills* bordering the same *valley* on opposite sides; a phenomenon again very contrary to the two geological hypothesis, that *running waters* have excavated *vallies*, and that they have disseminated the *gravel* now found above their level: the *valley* in question is that of the *Otter*, which I was again to cross. I have already said that the ridge of hills, separating this valley from that of the *Sid*, is covered with a very thick bed of large *flints*, in some parts united in great masses of pudding-stone. I now fixed my attention principally on the two eminences towards the sea, on one of which is the signal post; these are both cut down in cliffs to the sea, and are connected with each other only by a very narrow ridge, forming, on the outer side, a continuation of the cliffs, and, on the inner, bordering the *combe* which was before mentioned.

tioned. This state of things cannot certainly have been produced by running waters; yet both these eminences are equally covered with *flints*, as is likewise the slope of that on the west, down to the valley of the *Otter*, the opening of which valley is closed by a branch of the hills advancing on the side next the sea; in another of my journeys, I shall show this opening to have been a gulph; but at present, I only crossed the valley, and ascended the ridge of hills dividing it from that of *Ex*. Now here, after I had passed over the low hills formed of the *red strata* on the side next the *Otter*, I perceived no more *flints*; the slopes as well as the summits of the higher hills presenting nothing but rounded fragments of *grey wacke*, some of them not less than a foot in diameter. This is a very marked difference between the nature of the masses scattered on two parallel ridges of hills, bordering the same valley; and a circumstance which still more completely banishes every idea, that these effects have been produced on the continent since its birth, is, that it is impossible here to discover any source of the fragments, either of *grey wacke*, or of *flint*; and this consideration will be farther developed by the particulars observed in a subsequent journey.

770. I descended insensibly from the most elevated point of this ridge of hills, three miles before I came to *Exmouth*, and passed over some lower ridges, belonging to the same chain: on this side, as well as on that of the *Otter*, the lowest, hills are composed of

the *red strata*; and it is on one of these that the town of *Exmouth* is built, near the entrance of the gulph. I was here recommended by the Bishop to Mr. DUCARREL, to whom I went immediately on my arrival; and having explained to him the points which I wished to observe, he offered to accompany me, after breakfast, the next morning, to the hills on the eastern side, commanding a general prospect of all the objects that could interest me.

Oct. 1*st*. When I went to Mr. Ducarrel's house, he told me that he was sorry he could not give up so much time to me as he had intended, because he should be obliged to return early to *Exmouth*; but that he would go with me far enough to explain all the circumstances relative to the entrance of the gulph. As I had informed him that I intended to proceed the same evening to *Teignmouth*, he gave orders to his servant to have an one-horse chaise, with a guide, in readiness for me, when I should return from my walk.

771. We set out from *Exmouth* at half past nine; and Mr. Ducarrel first led me to a natural terrace, at the end of the first ridge of low hills consisting of *red strata*, which formed the eastern side of the *original gulph*, and on which a few years ago, was built a handsome row of houses, intended as lodgings for those who come to bathe on this strand, and for invalids, to whom the temperate climate of this southern coast is in winter very salutary. The mild-

ness of the winters at *Exmouth* is indeed shown by its productions; the houses, on their garden side, being adorned with flowering myrtles, and with the Magnolia grandiflora: vegetation, in general, is very fine around this gulph, where the trees do not suffer from the sea-air, as is so common on other coasts.

772. With respect to the geological objects of this place, it may be judged, by many symptoms, that the gulph, which is three miles across at its entrance, was at first open to the sea, whence it is now separated by two bars of sand of unequal breadth, advancing, in a parallel direction, one, which is the narrowest, from the eastern side, the other, which is very wide, from the western; and the latter has, on the southward, passed before the extremity of the former. The interval between the extremities of these two slips of accumulated sand is the only passage kept open by the land waters and the tides; and as, among the former, the most considerable is the *Ex*, which enters the gulph eleven miles above this, the name of *Exmouth* has on that account been given to the small town situated at the entrance of the gulph, with its port in the interval between the two slips of sand: vessels of 300 tons can pass here and ascend as high as *Exeter*. The cape advancing on the east, to which the above-mentioned terrace belongs, has its strata cut down abruptly towards what was originally the entrance of the gulph; and hereafter will be seen evident indications that in one of the latest catastrophes

phes the part separated from it sunk down under the level of the present sea. The cliff of this terrace consists of the *red strata*, in great part stony; it no longer suffers degradation, because it is encompassed by the slip of new ground advancing from this side. When the bars found at the entrance of the gulph had risen above the level of the water, the sediments of the *Ex* and of the smaller streams arriving in the interior space were retained within it; so that since that time, it is only by the sand of the sea, mixed with the little gravel which the waves have found on its bed, that these bars have been elevated and widened to a great breadth on the western side; and the winds have raised up the sand on them in dunes: they are sometimes pierced by violent winds continuing long in the same direction; but the breaches are soon closed by winds from other quarters, which are incessantly driving the sand along the shore. There is also at a little distance in front of the coast a sand-bank, occupying almost the whole breadth of the entrance of the gulph, and leaving only a narrow passage, on the eastern side, for the ships which are to enter the port: from the terrace, whence Mr. Ducarrel explained to me these different objects, all within our view, we distinguished this sand-bank, the tide being still high, only by the breakers in the sea; at low water, it is in great part uncovered.

773. After these observations, Mr. Ducarrel took me to the end of the terrace, whence we descended

on the strand, here still wide and passing before a *combe*, which comes down to the level of the sea, but of which the entrance is closed, not only by the gravelly strand, but by a wide ridge of dunes. The strand has continued to extend itself along the front of the following cliff, which also is now secured by it against the attacks of the sea. This cliff is formed of *strata* different from those of the above mentioned terrace, and belonging to a ridge nearer to the high hills; they are *red*, but entirely *argillaceous*, and bricks are made at their foot. Beyond this first *combe*, we came to another which we went up, in order to cross its upper part, and thence proceed on the hills advancing farther towards the sea and forming the cape. Having ascended these hills, we returned to the brow of the lateral cliffs, I mean those turned towards the gulph, along which Mr. Ducarrel showed me a path leading to the end of the cape; and leaving me here, he returned to *Exmouth*.

774. When I could reach a projecting part of this cliff, in order to observe its *strata* in some lateral section, I found them very different from the preceding, being in great part *stony*, and I saw them inclined inwards; so that, when I came to the end of the cape, where they are cut down in the same abrupt manner to the sea, I saw them descend obliquely eastward, the highest of them passing at a distance below the level of a strand formed at the foot of the cliff. The masses of these *strata* sunk

below the level of the sea have left some parts rising above that level, the most considerable of which bears the name of the *Shag-rock;* bscause the sea-fowl so called assemble on it sometimes in great numbers. I went down on the strand, whence the cliff has a very picturesque appearance: though it continues of the same height, its side towards the sea no longer presents the same *strata,* those which are at the greatest height on the side next the gulph having, by their inclination, passed successively below the strand. The *strata* seen on this eastern side differing in hardness, not only one from another, but each in its own peculiar composition, the waves, in beating against them, have produced in them very singular excavations of different forms; and of the masses sunk below the level of the sea some parts, rising above that level, produce a kind of succession of *needles,* some of them hollowed into arches under which there is room to pass at low water; but the tide was still too high, and the sea rough, so that I could not advance to these rocks; it made me some amends, however, to see the waves break against them, and foam as they passed through the arches, with a noise loud enough to be heard at a great distance.

775. I reascended the cliff up to its highest point, composed of *strata* under which the various *red* kinds have passed by their inclination; and I found the top covered with abundance of gravel of *grey wacke.* Turning then my back to the sea, I looked

towards the hills rising above this spot, and presenting a very agreeable prospect by the rich cultivation of their lower part; and in them I perceived the impression of the same catastrophes which show their effects in the cliffs. Here, as well as in many similar slopes already described, the terraces of the hills are evidently successive subsidences, always in the front of fractures more or less visible, down to the point, where, by a subsidence still more considerable, the masses of the strata, which extended themselves towards the space now occupied by the sea, have passed below its level, leaving the above rocks near the coast to point out what is become of them. But so great a disorder has been produced among the various species of *strata*, by the angular motions and slips of the separated masses, that it is almost impossible to follow in detail the progress of these catastrophes, to which it is owing that many of those species have been brought to view.

776. In returning from the cape, I followed at first the brow of the same cliffs along which I had already passed; but the tide being now low, and the strand in consequence much wider, I went down to it by a steep path formed in a wide fissure of the cliff. From this point, the strand, continuing to increase in breadth, goes on to join the eastern slip of sand, which, as I have said, projecting into the gulph, passes a considerable way behind the extremity of the western; the strand itself being also bordered with *dunes*, along all the part no longer

covered by the tides. Returning thus to the bottom of one of the *combes* already mentioned, I saw in the sea the section, now above water, of a mass of the *stony strata*, which, by their dipping inwards, evidently appear to have subsided; their ridge extends towards the *sand-bank*, being interrupted only near the point where vessels pass; whence I judged that here, as well as in many similar places before described, the formation of the slips of land, and even of the sand-bank, has been produced by submarine *bars*, consisting of those parts of the *masses* of sunken strata, which have remained near the level of the present sea. All this quantity of sand has been brought up from the bottom of the sea by the waves and the tides, as is the case with respect to all strands; a fact which directly opposes the idea that any materials have been carried from the land along the declivity of the bed of the ocean.

777. It was a little after one when I returned to *Exmouth*: Mr. Ducarrel's servant had procured for me an one-horse chaise; but, before I set out, I asked him to accompany me along the inner side of the gulph, where I saw a great extent of lands, which the tide, in retiring, had left uncovered: he told me that, at high water, these lands were in great part covered; but that they were gradually rising, and grass was spreading over them; so that it was now proposed to enclose them with an embankment, beginning at the extremity of the inner slip of land, and carried on to a cape at some distance called *Isling point*, to which I saw these lands extend: this is a very large

space, and will easily be converted into meadows, when the tides shall be excluded from it.

778. I crossed the channel of the port near *Exmouth*, with the chaise, and as it was low water, I found, on the opposite side, a good strand below the level of the dunes. The servant very civilly desired to accompany me in this passage, in order to explain to me such objects as should present themselves in the way to the other side of the gulph. The western slip of land is of a very great breadth, and consists entirely of *dunes* as far as to the outer strand. These *dunes* are covered with heath, thyme, and various other kinds of herbage; so that they swarm with rabbits, like those in *Holland*, and in SMITH's map this space is marked by the name of the *Warren*. The tide being low, I might have gone on to *Dawlish* under the cliffs; but I wished to see the upper part of the hills, and therefore proceeded on the *Warren* as far as *Starcross*, on the western side of the gulph. At present, however, I shall not speak of these hills, because I observed them more particularly the following year: I now passed directly over them to *Teignmouth*, where I arrived at four o'clock.

779. The Bishop had given me a very particular recommendation to Mr. SHORT, one of his chaplains, who was the clergyman of this place; which proved a most fortunate circumstance for me, as will sufficiently appear. To this gentleman I explained

what were the objects of my journey; and he was so good as to accompany me on some observations that same evening. *Teignmouth* affords a new example of the places which their names indicate as the *mouths* of *rivers*, though those *rivers* really arrive at the level of the sea at a considerable distance above them. This is an extremely pleasant place, near the entrance of an *original gulph*, encompassed, like those of *Exmouth* and *Sidmouth*, by very fertile hills composed of *red strata*, rising, in the form of an amphitheatre, against higher hills of a different nature. The entrance of this gulph was originally about a mile in breadth; but a double slip of land has extended itself, from the foot of the hills on the eastern side, where *Teignmouth* stands, very nearly to the western; whither consequently is transported, not only the passage of tides, but that of the *Teign*, a small river, the course of which, from its origin, I shall have frequent occasions to describe. These *slips of new ground* are here called *dens*; a word supposed to be of Danish origin.

780. This double slip of land, which, as I have said, begins from the *Teignmouth* side, and has almost entirely closed the gulph, is composed of sea-sand and small gravel; and I cannot perceive any other reason for its being thus forked, but that such was the form of a submarine *bar*, consisting of a part of the sunken *strata*; for had there been here only a simple bar, the sand and small gravel impelled against it by the waves and the ascending tides

would have produced a single slip of land. The outer branch extends under the sea in a gentle declivity, forming a strand of pure sand, very convenient for sea-bathing. The opening of this kind of fork being turned towards the channel of the tides, they formerly entered it; but, by their deposites they so much raised the bottom of the interval, that it became easy to convert it into dry land, by enclosing it, and at the same time confining between small banks a brook called the *Thame*, whereby *Teignmouth* is divided into two parishes, east and west. There is a very pleasant walk on the highest part of the outer *den*, the slope of which on the land side is covered with grass; but the sand raised by the winds from the strand, being scattered over that part, is tending to raise it; and Mr. Short has observed the progress of this operation to have been very sensible within the space of the last five and twenty years.

781. This very agreeable place having been lately much frequented on account of sea-bathing, some labour has been employed in raising the enclosed interval between the two *dens*, where I saw preparations for building; and *Shaldon*, which stands on the opposite side of the gulph, and was formerly but a hamlet, is now much increased for the same reason. The name of *Teignmouth* might indeed very properly be transferred to *Shaldon*; for it is on that side that the waters of the *Teign* flow into the sea, with the descending tides; two-masted vessels can pass there; and the port is within the gulph, against the *den*.

I took, this evening, a cursory view of the cliffs on the sea-side; they are composed of the *red strata*, and are very curious in respect both of their forms and of their composition: I shall describe them on a future occasion, because at present I had not time to inspect them more particularly, Mr. Short having the kindness to propose taking me the next morning towards the upper part of the course of the *Teign*, which it was my intention to observe.

Oct. 2*nd.* At half past nine in the morning we set out from *Teignmouth*, in an one-horse chaise, and first went up the gulph on its left side. In this road we again crossed two small hills composed of the *red strata;* the lower part of the *combe* between them forms in the gulph a cove, which is now almost filled up; for, the tide being out, we saw its bottom above water. Beyond these hills of *red strata*, we passed over one of a different kind, consisting of strata of *grey wacke*, often found, as I have already said, with the *schisti;* in this part of the country it is called *dun-stone*, and sometimes *iron-stone*, when it is very hard and heavy; and indeed a little iron is contained in it.

782. Having passed this hill, we descended towards the river, and passed it, six miles above *Teignmouth*, on a bridge, or rather a causeway with several arches, continued across the meadows. The space now occupied by these was originally a part of the gulph; for it is known by tradition that the tides

formerly rose up to the bridge; but at present the meadows extend a mile below it, and are continuing to increase, in proportion as the head of the gulph is filled up by the sediments of the *Teign*, of which the branches will be seen to embrace a great extent of the higher part of the country. Here, throughout a large tract, the original soil is low; its surface consists of *white sand;* and under this are strata of *white clay*, which, at the depth of ten feet, become pure, and are worked for potteries, like those at *Wareham*, covered likewise by *white sand;* (§. 677.) An excavation is first made here of about fifteen feet square; and when the pure clay is found, it is cut into cubes of seven or eight inches; these are dried under cover, like bricks, and are afterwards fit for carriage. Under these strata, the *white sand* is again found, into which the waters filtrate; and as they come down from higher ground, the workmen are obliged to use precautions, when they arrive nearly at the depth where the argillaceous strata cease; for these, when they become very thin, are broken by the pressure of the water from beneath; and the workmen are in danger of being drowned unless they immediately hasten up their ladder, the water sometimes filling the excavation very rapidly up to the level of the surface, at which height I saw it remaining in several of these pits: the same work is then begun again at some distance.

783. I was now approaching the region of *Dartmoor;* a ridge of interrupted eminences covered with

peat, which extends over almost the whole northern part of this peninsula, even beyond the river *Tamer* into *Cornwall*, though there no longer under the same name. I shall often have occasion to speak of this region, which I have observed in various parts, on account of its great importance for the decision of many geological questions. This is a country which Mr. Playfair, having travelled through it, ought to have studied with particular attention, in order to compare its phenomena with the various hypotheses contained in his XVIIIth Note, intitled, *Transportation of Stones;* where he tries to shew how the *blocks* of *primordial stones*, scattered in such vast abundance over so many countries, may have migrated on our continents from more elevated situations; a supposition by which an immeasurable antiquity in these continents is implied even more positively, than by the simple hypothesis of the formation of vallies by running waters. This being then an object peculiarly requiring to be elucidated by very numerous facts, I have entered into many details respecting it in the preceding volume; where I have, as I think, irrefragably proved, that, when our continents were first produced, these *blocks* were lying in the same places where we at present find them. But the countries described in that volume are not known to Mr. Playfair, (though he sometimes refers to them,) and are out of the reach of most of my readers, many of whom may be acquainted with *Devonshire* and *Cornwall*, in which Mr. Playfair himself also has travelled. Now it will be seen by the immense quantity of *blocks* of *granite* scattered over *Dartmoor*, which is the highest ground in this whole peninsula, and of which the mass, in its greatest extent, does not consist of *granite*, that, if he had observed this country attentively, he would probably have found reason to abandon his idea of the *migration* of *stones*.

784. Soon after we had crossed the *Teign*, Mr. Short brought me to a handsome house, built of *granite* very well hewn, belonging to Mr. TEMPLAR, who was not at home; but I had an opportunity of seeing him afterwards, when he confirmed to me what Mr. Short now told me, that this *granite* came from a neighbouring hill, which was one of the objects of this day's excursion. At some distance from Mr. Templar's house, we entered another large space, similar to the preceding, the upper soil being also of white sand, covering strata of white clay. The surface of this soil, which is of great extent, consists of heath on peat, and is called *Bovey heath*, from the small river *Bovey*, which falls into the *Teign*, and gives its name to several other places, such as *Bovey Tracey*, a small town in the vicinity, and *Bovey coal-pit*, where, on a rising ground, is found a combustible substance of a particular kind, called *Bovey coal*. Mr. Short conducted me to the latter spot, which I had much desired to see, on account of the various opinions entertained respecting this substance; but unfortunately we found the pit filled with water to a certain height. The excavation was already carried twenty feet below the point

at which the water can run off, and it was therefore necessary that the quantity oozing into it should be pumped out; but some differences having arisen among the proprietors, the steam-engine was no longer in action. The case was the same when I returned to this spot the following year; thus I was unable at either time to observe more than the part above the level of the water, where the work was going on.

784. *a.* The common opinion respecting the combustible substance here worked is, that it consists of of *wood:* from some specimens which my brother had brought to *Geneva* before I came into *England*, I had entertained no doubt of this; but I have thought otherwise, since I have been on the spot: however, I do not mean to speak decisively, because I have not been able to see the inferior strata, which are much thicker than those that I observed; but I shall explain for what reasons I became doubtful on the subject from viewing the latter. I saw there a large section of strata of a *greyish clay*, and between these, but at considerable intervals, other strata of a *brown* substance, being what is called the *Bovey coal.* The uppermost of these strata was only two or three inches thick; but the thickness of those which were lower successively increased, that of the lowest above the level of the water being nearly six inches.

785. The opinion that these *brown strata* consist of *wood* is founded on their aspect; and certainly

nothing can have a more ligneous appearance: they are foliaceous, and their laminæ, of which the surface seems fibrous, resemble chips of wood, there being even knots on some pieces; but simple *argillaceous* and *schistose* strata have sometimes the same appearance, and additional circumstances are requisite to render it certain that these are *ligneous*; now the following characters seem to me to be contrary to this idea. The first is the equal thickness of each *brown stratum* throughout its whole extent, even of that one which is not more than two inches thick; so that, were these strata really of *wood*, they must have been composed of sawn planks, evenly arranged as in a floor. This was the circumstance that first struck me; for I could not represent to myself any other manner in which these *strata* could have been formed, supposing them to consist of wood. It has been objected to me that the trunks branches and roots of trees might have become sufficiently soft to be flattened by the pressure of the superincumbent strata; but besides that this effect is never found in true *fossil wood*, such a softening of their substance could not have been produced otherwise than by maceration; an operation which, decomposing the *fibres* themselves, would have destroyed that *fibrous* appearance whereon is founded the opinion of their *ligneous* origin.

786. With respect to the other characters, I remarked that the pieces newly detached from the stratum might be cut with a knife, exactly like com-

pact clay, and shewed no fibrous appearance in the section; their smell being only like that of clay impregnated with bitumen. And indeed this substance cannot be burnt in houses, its bituminous exhalations being too strong; so that it is chiefly used in kilns, for lime, pottery, and bricks. Lastly, I saw, under the grate of a furnace, in which it was burnt, that the cinders consisted of a friable *white clay*, preserving their original form; thus it appeared that the combustion had been only that of the *bitumen* contained in this clay; and the workmen showed me masses of pure *bitumen* found in the same strata.

787. Mr. Short, indeed, pointed out to me one circumstance apparently favourable to the opinion that these *strata* are *ligneous;* namely, that, in a lower soil surrounding this pit, stumps of trees with their roots, like those left in forests where trees have been cut down, are found in great abundance, under *peat*, and resting on the *white clay* already mentioned; many of them had been newly taken up from under the peat, in order to be used for fuel, like other wood; and I was told that, among these, entire trees were sometimes discovered. But this is only a superficial phenomenon, which, like all those belonging to peat, has been certainly produced on the continent, subsequently to its birth; trunks, branches and roots of trees being commonly found on the bottom of all *peat-moors*. But no cause, since the continent has existed, can have produced

on it this great thickness of *argillaceous strata*, parallel with each other, and alternating with the *brown strata* which form our present subject: and moreover, all these have undergone the catastrophes common to our other mineral strata, since they incline inwards, and present their section at the surface. These are my reasons for believing such of the *brown strata* as I was able to observe, to consist only of *clay*, impregnated with *bitumen*; but I decide nothing with respect to those concealed from me by the water, which, as I was informed, continue to increase in thickness as they become deeper, that of the lowest even exceeding five feet; but each of them, throughout its whole extent, preserves an equal thickness, and parallelism with the other strata; which renders the first of the above considerations applicable to the whole mass.

788. To the N. W. of this place rise the first of the eminences belonging on this side to *Dartmoor*; and to these Mr. Short was so good as to conduct me. We went first to *Bovey Tracey*, where we left our chaise, because it was on foot only that these hills could be ascended for the purpose of observation. In the first part of our way, I saw that the road had been cut through the *greywacke*, which, as I have said, is called *dun-stone* in this part of the country, and appears, with the *schisti*, to constitute the mass of the hills; but, when we came to a certain height, we found these strata entirely concealed; *blocks* of *granite*, some of which are immense, here resting

on a very thick soil, formed of a coarse *sand*, apparently consisting of decomposed *granite;* neither from its own aspect however, nor from any appearance of decomposition observable in the *blocks*, does it seem to have proceeded from the latter, which are covered with grass, mosses, and lichens. This *sand* is an interesting phenomenon, belonging to the whole of *Dartmoor*, and extending itself into *Cornwall*, under different forms, with circumstances which may contribute to determine its nature; I shall therefore defer speaking of it, till I come to the account of my travels in *Cornwall*.

789. The hill which I am now describing, and which is called *Furzeleigh* from the furze that covers it, presents likewise the first example of another phenomenon common to the whole space above indicated; this consists of masses of *granite*, seemingly belonging to the hill, although its own mass is composed of *schistus* and *dun-stone*. Here and there are columns apparently formed of piles of *blocks*, which cannot have been thus arranged by any exterior cause; but, in particular, there are rocks of *granite* rising above the grass, one of which, on *Furzeleigh*, is very large and high; and great numbers of these rocks are seen from this hill on other parts of *Dartmoor*, all bearing the common name of *Tors*, or Towers. I shall describe, in the course of my travels, such rocks of this kind as I had occasion to observe, and all that is known of the mass of the eminences on which they rise. In descending this hill on the side

opposite

opposite to *Bovey Tracey*, where the slope is covered with *blocks* on the same sand, we passed near a *rock* of *granite* resembling that on the summit, and called the *White stone*.

790. Having returned to *Bovey Tracey*, where we again got into the chaise, Mr. Short took me to another spot, very remarkable on account of the surrounding objects. Thus far we had found the ridge of hills whence we had descended, which slopes down to the banks of the *Teign*, to consist wholly of schistus intermixed with dun-stone; but after having passed that river on a bridge, not far from *Chudleigh*, I saw the first example of effects very common in this county, and occasioned by the catastrophes which have affected the strata, and mingled them together externally in the most astonishing manner. This was the great mass called *Chudleigh rock*, entirely insulated, and composed of *marble*. There are quarries all around this eminence, whence blocks are taken; the marble differs in colour in the different strata, but having in all sparry veins, and being susceptible of a very fine polish, it is used for various purposes in the internal decoration of houses; and the rubbish is burnt for lime, as well as those parts of the strata which are too much fractured to contain any large masses.

791. The *strata* of this large calcareous rock, which I observed more particularly in a subsequent journey, descend very rapidly from east to west.

This mount is separated from a neighbouring hill of greater height, (whereon is the seat of Lord Clifford,) by a very deep ravine, into which we descended, having sent the chaise to wait for us at its issue. We here saw the same *strata* on both sides up to a certain height, the hill rising above that point in a grassy slope. A little stream, called *Ugbrook*, flows in this interval, which it certainly cannot have excavated, since there is a high *cascade* in this part of its course. Moreover, when the two sides are here compared, the *strata* are seen to have different inclinations; and this indicates a fracture, with different angular motions on its opposite sides, and unequal subsidences; from which latter circumstance, in particular, has resulted the unevenness of the bottom of the glen, where the brook must have thus fallen in a cascade, ever since it began to flow.

792. We took the chaise on issuing from the defile, and ascended the hill by an oblique road, in front of the rock. The strata cannot be perceived on this slope, because it is covered with a very thick loose soil; this is the case likewise on the hill itself, within Lord Clifford's park, which we crossed; but here and there are seen masses of the same calcareous strata raising their summits above the grass. On quitting the park, we found the hill preserve for some way the same elevation; we then descended it on the *Teignmouth* side, and when we came to the bottom, near the course of the *Teign*, we there again

saw the strata of *dun-stone*, which we had observed in the part that we had passed in the morning. From hence we returned to *Teignmouth*, where we arrived at eight in the evening.

Oct. 3rd. Mr. Short knowing that it was my intention to proceed along the coast to *Plymouth*, and not satisfied with having been at so much trouble on my account the day before, insisted on taking me to *Torquay* in his own chaise, in order to point out to me some interesting objects in *Babicomb bay*, which lay in the road; and Mr. OXNAM, a clergyman of *Exeter*, accompanied us on horseback. We went first to the extremity of the *den*, or slip of land belonging to *Teignmouth;* and having crossed the channel by which the water of the *Teign* is discharged into the sea, we arrived at *Shaldon*, whence ascending a steep hill, we had from its top a view of all the country over which we had passed the day before, as far as *Bovey Tracey* and *Furzeleigh hill*, and could perceive the connection of the latter with the rest of *Dartmoor*.

793. I found here a new example of the phenomena indicated under the XIIIth Head of the Introduction to these Travels, namely, that of *vallies* or *combes* parallel to the coast; some combes even, originating on the heights which command the sea, turn afterwards to a distance from it in their descent; and these cannot have been excavated by running waters, since there is no extent of upper grounds where waters can be collected to form a stream. From the

top of this hill above *Shaldon*, which borders the coast, there are seen on the land side, among lower hills, several vales, or very long combes; and the slopes of these, though for some way nearly parallel with each other, take afterwards different directions. The first, called the *Vale of Stoke*, is very wide; its bottom is covered with meadows, and a brook, which flows in it, turning away from the sea, throws itself into the head of the gulph of *Teignmouth*. The next is at no great distance; its slope is in a contrary direction; and the waters collected in it from several lateral combes are discharged into the sea near *Minicomb*. A third is divided into two branches; the waters of one being carried into *Babicomb bay*, while those of the other, which continues longer parallel to the coast, fall into *Torbay*. Such an assemblage of long *combes*, originating near the coast, with slopes in different and even opposite directions, can be explained only by the catastrophes of the *strata*; but of these more striking effects will presently appear.

794. We soon came to *Watcomb cove*, the first place in *Babicomb bay* which Mr. Short had intended to point out to me. In the lands within a certain distance of the coast, are here observable the fractures and dislocations of the *strata*, whence have originated the several *combes* descending towards this bay; some coming down to the shore, others terminating at the top of the cliffs, which they indent in large scallops. The masses divided by these frac-

tures having subsided gradually more and more on the side next the present bed of the sea, not only compose various terraces one below another, but, at the formation of that bed, large fragments, detached from the rest, have fallen, in the most chaotic confusion, on its new borders. This begins to appear in a very striking manner in *Watcomb cove*, and presents a scene no less beautiful than instructive. Here again the whole upper part of the cliffs is composed of the *red strata;* they are stony, some of them consisting of pudding-stone or breccia, wherein the fragments are of *grey wacke*; and small mounts are formed by large masses of these strata, which have fallen forward. Now this effect, as is very evident, must have taken place at the birth of the continents; for since that time, no cause has existed capable of dividing these masses; and that there is none tending to destroy them is also evident, from the grass which covers all these mounts, and affords pasture to sheep.

795. From *Watcombe cove* we proceeded southwards on the eminences above *Babicomb bay*, and crossed a ridge of hills of considerable height, still consisting of *red strata* in the form of pudding-stone; farther on, in the same direction, another similar ridge comes down and also terminates above the cliff in the bay; but between these two, is a lower ridge, which is composed of *marble* of the same species as that of *Chudleigh rock*, very beautifully variegated; there are quarries in the lower part of it, near the

beach. The course of this ridge of *marble strata* may be easily distinguished, within the land, by its form: it follows the foot of the highest ridge of the red strata, and terminates at some distance in a large space belonging to a combe: this space offers to the view a concavity embellished with the most lively verdure, and scattered with a profusion of trees. These large low spaces, very frequent in *Devonshire*, the production of which cannot be ascribed to running waters, have in fact the same origin with the *vales* and the *combes*; they are partial *subsidences*, more considerable than those that have taken place around them; and near them we very often find brought up to the surface, at the same level, different species of *strata*, one of which must have originally rested on the other; as is here the case with the *red strata*, certainly formed on those of *marble*.

796. The loose soil of the surface of these hills, covered with turf, renders it impossible to perceive, either the point where the stony strata change, or the nature of their association, which appear only in the abrupt side fronting the sea. In order to observe this section, we descended from the ridge of hills consisting of the *red strata*, on those of the *marble*, and advanced some way on a low promontory forming the southern side of another recess of the cliff, called *Hoddicomb cove*, the aspect of which is truly astonishing. Here, within a certain extent, the *marble strata* are seen to issue from beneath the *red strata* of the large hill, and to form in its front several

mounts of irregular figures, descending down to the shore, where there is a house for the workmen who belong to the quarries. This *cove*, formed in the *bay* like the preceding at the epoch of the vast subsidence which produced the present bed of the sea, is a part where that subsidence was less complete, but extended farther into the mass of the strata then become the border of the continent; so that the *red strata*, falling forward under the water, discovered those of the *marble*, which had lain beneath them in the high ridge of hills formed, like all the other sinuosities of the surface, by anterior revolutions on the bed of the ancient sea. The differences of the *strata* at the same level, common in this country, will successively shew that the catastrophes which produced the *form* of the *surface* of our continents must all be referred to a period prior to their birth.

797. The *strata* of the *marble* here, like those in *Chudleigh rock*, differ in colour from each other; so that several species of fine marble are taken out of these quarries, besides a black kind with white veins, which is the most common; but it will be seen further that, within the extent of the bay only, from hence to the southward, there are very different calcareous strata at the same level. One of the great beauties of *Hoddicomb cove* results from the different inclinations of the sides of the mounts composed of the *red strata*: these mounts are as little subject to erosion as those of *Watcomb cove*, being also covered with grass; but some of their sides are formed by the

planes of the strata, the slope of which is so rapid, that the grass growing there consists of slender blades, very thinly spread; thus in the parts immediately opposite to view, the red soil, whence these blades spring, is seen betwixt them, while it gradually vanishes on both sides, as well as in the parts above or below the eye, where the surface appears quite green: so that all these mounts look exactly as if there were thrown over them a shot silk, of which the warp was red, and the woof green.

798. Having reascended to the higher part of this beautiful amphitheatre, and continuing our road to the south, we crossed the other ridge of the high hills composed of strata of *red pudding-stone*, and came down to a beautiful *combe*, extending a great way into the land, and adorned with abundance of trees, and hedge-rows in all directions, dividing the fields around a village. As we ascended the opposite side of this *combe*, we found the *strata* change; the *red strata* and the *marble* here giving place to those of a greyish *lime-stone*, more regular than the preceding relatively to each other, but all fractured, and in very great disorder. From this point, the bay turns as far as to the cape called *Hope's nose*, which terminates it on the south, and belongs to the promontory dividing it from *Torbay*. In the intermediate part there lies another recess, called *Anstis cove*; this I saw only from a distance; as after having passed the *combe* above mentioned, we went strait towards *Torquay*.

799. As we crossed the promontory separating the two bays, I could have fancied myself on certain summits of the *Jura*, where the *lime-stone strata*, dipping internally, shew at the surface their sections, rising in separate masses above the grass. This is exactly the case here; the surface of the hill being studded with rocks, which are the points of the lime-stone strata whereof its mass is composed; so that, if the upper part of one of those summits of the *Jura* towards a valley could be taken off, to the depth of five or six hundred feet, and set down by the sea-side, it would form a very accurate representation of this promontory. There is, as I was told, a succession of caverns within this mass, resembling those of the *Mendip hills*, which I shall hereafter describe: the caverns here have the name of *Kent's cave:* the *Jura* contains many of the same kind. And a still farther mark of the astonishing disorder into which the *strata* have been thrown in their catastrophes is, that, on the other side of this ridge of hills, the *schisti* begin to appear, and continue towards the west; where, between their ridges, those of *lime-stone* intervene, in the same manner as they do here between the hills of the *red strata.*

800. *Torquay*, at which we arrived at half past three, is a place of the greatest natural beauty: at that time, it was a very busy scene, every thing being in preparation for adding to its extent. This is one of the most favourable situations for enjoying in winter the mild climate of this southern coast; for

the village, lying in a deep cove on the northern side of *Torbay*, is open to the south, and is, at the same time, protected from the north and north-east winds, by the high hills encompassing it. These hills descend in successive terraces, covered with grass and trees, on which some new houses were already erected. I saw men at work also in widening the quay, where more houses were to be built; and a large pier had been formed to secure it against the waves: rough marble is used here for all these purposes. The new port is capable of receiving vessels of two hundred tons.

801. Mr. Short and Mr. Oxnam, being obliged to return in the evening to *Teignmouth*, had depended on finding at *Torquay* some gentleman of their acquaintance, to whom they could transfer the office of directing me in the ensuing part of my journey; and very fortunately for me, they met there with another clergyman, Mr. Kitson of *Ashburton*, who was not only for the present time, but afterwards, of the utmost assistance to me. This very evening, after my former friends had left me, he walked with me, over the heights, to the end of the promontory which separates the two bays, and commands a view of both. On the side towards *Babicomb bay*, I saw the coast to the northward as far as *Exmouth*; and I could distinguish by their forms and colours all the cliffs that I have lately described. We looked down on the singular cape of *Hope's nose*, in front of which two large rocks rise in the sea; these also are called

Shag rocks, because the birds of that name retire to them, and build their nests there. The sea is deep enough between these rocks to admit of the passage of vessels. I described masses of the same kind in *Watcomb cove* belonging to *Babicomb bay;* but the latter have remained connected with the coast; whereas those of *Hope's nose* are in the bed of the sea itself, above the level of the rest of the sunken *strata.*

802. In the elevated spot where we stood, the strata have undergone a great fracture, which extends towards *Babicomb bay*, and is sufficiently widened on the side next the open sea, to have large ash-trees growing in the cleft. The *marble* of this part of the hill is black with white veins, which are crevices in it filled up with spar: its mass is shattered to such a degree, that the *strata* are scarcely discernible; and as I was trying to discover them in one of the quarries, the workmen told me that they distinguished the divisions, by the facility with which blocks belonging to one stratum were removed from that below it, both retaining a smooth surface where separated; but that they found these lines in various directions in different parts of the hills. The crevices fillled with spar were antecedent to the great catastrophe that formed the bed of the sea; those produced at that epoch, some of them very wide, have been filled with red clay, which, to a certain depth, has communicated its colour to the spar of the ancient crevices adjacent to the sides of these later fissures.

On returning from this walk, I told Mr. Kitson that it was my intention to go round *Torbay* in my way to *Dartmouth;* and for this purpose he had the kindness to offer me his one-horse chaise, with his servant; I accepted it with great thankfulness; and I was under still greater obligations to him in the journey which I made the following year.

Oct. 4th. I set out at nine in the morning, and at first pursued a road cut along the interior slope of the hill composed of marble strata, which embraces the cove wherein *Torquay* is situated. The upper part of this hill, as will appear in the sequel to be the case with others still higher, is covered to some depth with a *sand,* certainly not the detritus of the *marble;* this upper part is called the *Warren,* because abundance of rabbits burrow in the sand. Hence we descended into a spacious combe, wherein *Tor Abbey* is situated. This combe opens on a wide strand, which extends a considerable way when the tide is out, as it was when I passed. It appears that the lower part of this combe was at first occupied by the sea; and that being filled up by a soil covered with peat, this soil has slipped forward beneath the level of the water; a phenomenon of which I shall give a more precise example in *Somersetshire.* The servant having told me, that when this soil, now left uncovered by the retreat of the tide, had been beaten by large waves, trees, roots, and branches, were often found in it, I advanced upon it, and actually saw branches and roots appearing here and there above the surface; but I could not pull them out, probably because they belonged to whole trees buried in that sand, which contained some lumps of peat.

803. All the borders of the inner part of the bay have been raised by the sand, and a gravel composed of fragments of *schistus* has been impelled by the waves against the foot of the cliffs: this beach, which passes also before the entrance of the combes, (including that of *Tor Abbey*,) serves as a dike to secure their meadows. The cliffs bordering this most remote part of the bay are the extremities of several ridges of small hills consisting of *red strata*, separating the *combes*. The red fronts of these cliffs form a very agreeable contrast with the fine verdure which cloaths the ridges and their intervals. One of the low hills ends in a cape, called *Livermead point;* this is encompassed with meadows; and neither roots, branches, nor peat, are seen in the strand formed by the waves before its extremity; it being only in front of the combes that these can have been brought by the sliding of the soil. We crossed the upper part of this hill, whence we descended to a cove between two capes; of these the first is called *Paington head*, from the name of a village lying in the interval between it and the following, which is called *Goderington head.* In this space meet two *combes*, separated by an eminence in the form of a sugar-loaf. The part below their junction appears to have been likewise occupied by the sea, and is covered with horizontal meadows; these are protected by a beach

raised by the waves in their front, and the strand itself is of sufficient extent to be marked in the maps by the name of *Paington sands*. The rivulets which issue from these *combes* are so inconsiderable, that they lose themselves in the gravel.

804. Here the strata change at the same level; as the cape called *Goderington head* belongs to a ridge of hills composed of *lime-stone strata*, which is seen advancing from a distance, and extends, with some interruptions, along all this side of the bay. After having crossed this ridge, I descended into a large *combe* terminating at *Churston Ferrers*, still within *Torbay*. It cannot be by the waters that this *combe* has been excavated; for not only did I see none flowing in it, but, from the difference of the *strata* composing its opposite sides, it is evident that their catastrophes must have been the cause of its formation. At this point begins that strange intermixture of the hills of *lime-stone* and *schistus*, which will be seen to extend to a great distance. I had descended into this combe from the ridge of *lime-stone* hills just described; and in ascending the opposite side, which is much higher, I found myself on the *schisti*. When I had here reached the most elevated point, I had a very fine view of *Torbay* and the hills encompassing it; and in looking down on this prospect, I perceived a new symptom of the dislocation undergone by the *strata* in their catastrophes, which again shews how little necessary it is to have recourse to running waters, for the purpose of explaining the deepest

sinuosities in the surface of the continents. The ridges of hills composed of *red strata*, terminating at the head of the bay, which are so different from those on its two sides, and divide simple *combes*, where rivulets alone are formed, and where the bottom is occupied by meadows, do themselves consist of separate *mounts;* a circumstance which cannot, in any imaginable way, have been produced by the waters.

805. The cause of all *vallies* is again characterized by the arrangement of the ridges of hills of *lime-stone* and *schistus*, here immediately succeeding each other. We are now approaching the *Dart*, which is the largest of the rivers rising in *Dartmoor*, and discharges itself into the sea, in the northern part of *Start bay*. This bay is separated from *Torbay* by a wide promontory, terminated by two capes; *Berry head*, on the side of *Torbay*, and *Cape Forward* on that of *Start bay*. This promontory, however, in the part where I crossed it, that is to say, from *Goderington* by the side of *Torbay*, to *Gampton* on the left bank of the *Dart*, is much narrower than it is towards the sea. Now the ridge of *lime-stone*, which forms *Berry head*, passes obliquely across this promontory, as it likewise does across the valley of the *Dart*, at a point where the latter is very wide; so that all the southern part of the promontory, from *Gampton* to *Cape Forward*, is of *schistus*. It is thus that the ridges of *schistus* and of *lime-stone* continue to be intermixed at the same level throughout a great ex-

tent of country, which I shall describe in the course of the present journey; but in that of the year after, when I followed the *Dart* to its rise in *Dartmoor*, it will be seen that in the parts where the subsidence of the *strata* was not succeeded by such great angular motions of the divided masses, the strata of the *limestone* rest on those of the *schisti*, as having been posterior to them in their formation.

806. When I had advanced far enough towards the southern part of this promontory, I had a very extensive view of a narrow gulph, which the *Dart* enters eleven miles above *Dartmouth*, where it arrives at the level of the sea, it being to this point that the tides ascend. On both sides are seen several *combes*, some of them descending to the level of this narrow and winding gulph, and others terminating at various heights above that level. By one of those of the former kind, I went down to *Kingswear*, a village situated on the left bank of the gulph, in its widest part near the sea, and opposite to the town of *Dartmouth*. This *combe* is very broad above, where it is encompassed with several eminences, in one of which is a quarry where slates for roofs are dug. But below this, the *combe* contracts gradually like a vast funnel, and at *Kingswear* becomes very narrow. All the waters arriving in this space, and flowing down to the narrow part of the *combe*, form a current too small to keep a mill constantly going; and when I passed by, I saw men at work in digging a large reservoir, for the purpose of collecting water in rainy

seasons,

seasons, and retaining it for times of drought. It cannot then be the waters which have here formed either the wide space above, or the contracted part below; nor is there any occasion to seek an origin for this *combe*; for the strata of *schistus* are almost vertical on its highest side, which is that nearest the sea, where the summit is formed by their sections; and they could not have assumed this position, but in consequence of a great fracture, and the subsidence of one of their masses, whereby a space was produced for the angular motion of the rest. It was one o'clock when I arrived at *Kingswear*, whence Mr. Kitson's servant took back the chaise to *Torquay*, and I crossed over in a boat to *Dartmouth*.

807. The *Dart* is the first of the rivers referred to by Mr. Playfair, p. 369, as rendering it, in his opinion, *perfectly clear*, that the *breaches* in the *rocks* on the coast, *by which rivers make their way to the sea, have been produced by their respective streams*. We have already seen *three rivers* to the eastward on this coast, the *Sid*, the *Teign*, and the *Ex*, to which such an operation cannot be attributed; and I shall shew that it is the same with the *Dart*, and with all the other *rivers* that he has enumerated, as well as with several intermediate ones.

808. At *Dartmouth*, the Bishop had given me a recommendation to Mr. ROCKET, the clergyman of St. Saviour's church; I called at his house immediately on my arrival; but not finding him at home, I

walked out of the town, after making a few inquiries, in order to take a first view of the part of the gulph extending from *Dartmouth* towards the sea. Having passed along the quay, I ascended a very steep street, prolonging the town up the almost perpendicular slope of a hill, the foot of which is of some extent, with houses and gardens on it; but as for the houses at the top of this street, it has been necessary to cut away and level the rock, in order to form the terrace on which they stand. I proceeded here as far as I could, without losing sight of the harbour, which, from this height, has only the appearance of a fine lake, surrounded by hills covered with trees and verdure. I did not see from hence the opening of the gulph to the sea, because the ridge of hills bordering the coast of *Start bay*, and nearly closing the gulph, concealed from me its mouth, which is on the opposite side; nor could I, on the other hand, descry its prolongation inland, because above *Dartmouth* it makes a turn. I therefore beheld nothing but a fine basin, having on one side the town of *Dartmouth*, with the shipping lying before its quay or at anchor, and on the other side *Kingswear*, which, with its gardens on terraces rising one above another, forms a charming amphitheatre; the rest of the circumference is composed of ridges of woody hills, presenting a most agreeable variety of aspects. In this part of the gulph the water is very deep, and it continues so to some distance above *Dartmouth*; so that this basin would be capable of receiving ships of the line; a circumstance which here I only indicate.

809. On my return from this walk, I had the pleasure of finding Mr. Rocket; and, when I had explained to him the objects of my journey, and the kind of observations that I had in view, as well on the river *Dart* itself, as at the place called its *mouth*, he was so good as to walk with me to the opening of the gulph, by which the water of the *Dart*, having entered its farther extremity, must pass off. It is for this reason only that the town has the name of *Dartmouth*, as we have already seen that the names of *Teignmouth*, *Exmouth*, and *Sidmouth*, are given to places near the *openings* through which the waters of their respective *rivers* enter the sea with the ebbing tides. Three other gentlemen of *Dartmouth* joined us in this walk, one of whom, Mr. Newman, afterwards assisted me in the prosecution of my journey.

810. These gentlemen first led me to the top of the hill, the slope of which I had already, in great part ascended by the street above described. As this hill rises above those that border the coast, it commands a view of the whole extent of *Start bay*, bounded on the south by *Start point*. Towards the middle of the bay, I descried an object which had attracted my attention when I had seen it in the map; namely, a piece of water extending in a direction parallel to the coast, and represented as entered at one end by a

small stream, though without an issue to the sea This piece of water is a kind of lake, and is called *Slapton lee*, from the village of *Slapton*, which stands near it. I told the gentlemen who were with me that it was my intention to go to observe this lake, continuing to follow the bay as far as the succeeding gulph called *Portlemouth;* but they dissuaded me from my plan, both on account of the bad roads along the bay, and of the difficulty which I might find in crossing that gulph, no ferry-boat being kept there; they told me likewise that I should find more interesting objects to observe, if I went round by *Kingsbridge;* and as they at the same time explained to me all that I wished to know respecting the particular object which I had in view, I shall here describe it according to the information that I received from them.

811. *Slapton lee* occupies the lower part of a *combe*, which at first formed a recess in the bay; but the sea before it being shallow, the waves brought up the gravel from the bottom along the coast, and the *beach* thus produced passed at length quite across this recess, which it closed: since then, the *fresh water* proceeding from the combe has almost entirely displaced the *salt water* within this space; because the former arriving there freely, and passing through the gravel of the beach, repels the small quantity of the sea water which filtrates into it; an operation of which this same coast will afford me other examples. In seasons of long rains or sudden

thaws, the *fresh water*, coming down into this *lake* in great abundance, rises to the level of the *beach*, and cuts through it at some point where it runs off; but when these floods cease, the bank is soon repaired by the waves. *Slapton lee*, which is about two miles in length, and a quarter of a mile in its greatest breadth, is a little brackish, on account of its communications with the sea-water, as well through the gravel in common seasons, as when there is any opening in the beach; however it contains fresh water fish, carp, tench, and pike. The sediments of the land-waters are tending to fill up this basin, and wherever the bottom is sufficiently raised, reeds are beginning to grow; which is always the prelude to a soil convertible, in the course of time, into meadow land.

812. The high hill, whence we had this view of *Start bay*, descends on its opposite sides towards two vales, one of which terminates in the gulph above *Dartmouth*, and the other follows the inner side of the lower hills near the sea, that contract the entrance of the gulph. The lower parts of these *vales*, or very wide *combes*, were originally *creeks* in the *gulph*, which the sediments deposited by the tides have tended from the beginning to fill up; meadows being now formed on those deposits. We descended into the vale nearest the sea, and passed through the village called *Little Dartmouth*; whence we ascended the hills skirting the coast, from which we saw that the very wide strand bordering the whole bay had

repelled the sea to a considerable distance. We proceeded along the brow of these hills to the extremity of the cape contracting the entrance of the gulph, where the water is very deep: we then went round the cape, passing above *St. Petrock's castle*, which defends the entrance of the gulph; and continuing to follow the brow of the hill by the side of the gulph, we came down into the meadows of the filled up creek on this side where we crossed, on a bridge, the channel of a rivulet which in rainy seasons issues from the combe, but was then dry.

313. All the *creeks* of this long *æstuary* from *Dartmouth* to *Topness*, being likewise the extremities of *vales* or of *combes*, have the same tendency to be *filled up*, by the sediments of the land-waters, and the deposites of the tides; a fact of which these gentlemen showed me a second example in the town of *Dartmouth* itself. This is a creek retaining the name of the *Mill-pond*, because a *tide-mill* formerly stood there, of the kind already explained: but that establishment has been abandoned, since the construction of a large pier, called *New ground*, which has produced a secure port; and the *Mill-pond* is now converted into a dock; the tides still enter it, but I saw it dry at low water. Farther on in the gulph, but at no great distance above *Dartmouth*, the extremity of the other combe already mentioned is also in great part filled up, as is indicated by the name of *Combe Mud*, given to it because, at low water, its entrance consists entirely of mud: how-

ever the waves have raised a beach before it, and a dock has been made in it within these few years, by means of another pier to keep off the waves coming in from the sea.

814. I had already an intention of going up this large æstuary as far as *Totness*, in order to observe the hills of *lime-stone* intermixed with those of *schistus*; being persuaded that the ridge of the former, which begins at *Torbay*, must necessarily be intersected by the gulph: but these first observations on the filling up of the creeks within it had now given me an additional motive for wishing to see the upper part of it; and on mentioning my plan to Mr. Rocket, he was so kind as to offer to accompany me the next day in this little voyage; for which he accordingly bespoke a boat, with a sail and two rowers.

Oct. 5th. We set out from *Dartmouth* at noon, with the ascending tide. In fine weather, such as we fortunately had, it is extremely pleasant to sail in this gulph, on account of the continual changes of prospect produced by its windings between the ridges of hills coming down to it, and the combes successively passed, in which villages are situated. Vegetation is very rich over all these hills, and comes every where down to the high-water mark; so that it is only in the space between that line and the actual level of the water, that the *schisti* can be seen uncovered; and this zone was then of sufficient breadth to show the state of the strata in the hills.

815. This long gulph having great inflections, and its sides being intersected with combes, as we sailed along by the above mentioned zone, we saw the *strata* appear in it under the greatest variety of aspects: they are, in general, very much inclined; but in different hills they change, both in degree of inclination, and in direction; so that there are parts in which they present their planes towards the gulph; others where they slope backwards; but in most places they descend laterally. All these are evident signs of the catastrophes which the strata have undergone.

816. The lower parts of most of the *combes* were, at the birth of the continents, occupied by the sea, having been left below its level; but the sediments of the tides, and of the land waters arriving there, have been tending ever since to fill them up; and on these new grounds, meadows are formed, as horizontal as the water of which they have taken the place. In some of the narrow parts of the gulph, the *salient* angles on one side correspond with the *retreating* angles on the other; but here is also found the confirmation of a remark of M. de Saussure with respect to this phenomenon. The idea of BOURGUET, adopted by BUFFON and other geologists, that *mountains* had been formed beneath the waters of the sea along its currents, was founded on a pretended regular correspondence between the *salient* and *retreating*

treating angles in *vallies*; and this idea was considered as very important, at the time when Bourguet published his system. But M. de Saussure shewed, by his observations in the course of his travels, that the above is very far from being a general phenomenon; that vallies are frequently contracted by opposite salient angles, and then become wider by the retreat of the mountains on both their sides; and of this fact, which was no less contrary to the system that vallies have been excavated by running waters, than to that of M. Bourguet, examples will presently appear in the gulph of *Dartmouth*; it being merely an original *valley*, the bottom of which happened, at the birth of the continent, to be below the level of the sea.

817. After we had sailed for some time, following the windings of the gulph, we entered a large space, where the hills become lower at the same time on both sides; and this part, as Mr. Rocket told me, is very dangerous for boats and barges in stormy weather; because, if there be a side-wind, these openings of the hills give it a free passage. It is here that the great subsidence of all the strata has occasioned an interruption in the ridge of *lime-stone* hills terminating towards the sea at *Berry head*, and following an oblique direction, relatively to that of the gulph; so that, our course leading us into a large cove on the left bank, we saw quarries in the section of the *lime-stone strata*, though on both sides of the latter the *schisti* appear. It will be seen, in my next

journey, that, the section of this *calcareous* ridge again shews itself higher up, on the opposite side of the gulph; but we had not at present an opportunity of observing it. As for any correspondence between the sides immediately fronting each other, after having crossed the wide space just mentioned, we came into a part much contracted by the extremity of the *lime-stone* ridge on the left bank, and a promontory advancing into the gulph from the right bank, which is composed of *schisti*, and is very remarkable in other respects; there being across its breadth a cleft deep enough to form a vale, containing the village of *Dittisham*, which is entirely hidden from the gulph: we saw its steeple in this cleft, as we approached the promontory, and it appeared again when we reached the opposite side. How could any running waters have excavated this *vale* across an eminence?

318. As we approached *Totness*, we began to find shoals; it being mostly in this remote part of the gulph that the *Dart* and its branches deposite the materials which they wash from the land in their inundations. We arrived here some time before it was high water, when these alluvial grounds being still uncovered, we saw a great extent of them; they were overspread with grass in the parts which were most remote, and consequently most elevated. We landed at *Totness* quay, and thence went up to the town. Here the sides of the gulph are brought so near to each other by opposite promontories, sloping

down to the water, that a bridge is built across it: the principal part of the town is situated on the slope of the promontory on the right bank, and another part called *Bridgetown*, rises on the slope of the opposite promontory.

819. A more beautiful prospect could not easily be found than that which is seen from the middle of the bridge, of the country whence the *Dart* arrives here. From this point, the hills, receding on both sides, embrace a large space of meadow land with the river winding through it towards which the hills, branching into several ridges, partly cultivated, and partly covered with wood, descend in a gentle declivity, the most remote of these hills belonging to *Dartmoor*. The tides ascend much higher than *Totness;* so that all the space within their reach above the bridge originally constituted a part of the *gulph*, though now occupied by these meadows, formed on the sediments of the tides of the *Dart*, and of all the brooks which descend from the surrounding combes; these sediments are still deposited below the bridge, and whenever they rise above the level of the greatest inundations, new meadows are formed on their soil.

820. In order to obtain, at *Topness*, a fall for mills, it has been necessary to bring the water from a remote part of the river, by a canal cut along the foot of the hills on the right bank. At the time when I was there, the stream itself, confined within its

common channel, was of very inconsiderable size, its course not being yet stopped by the tide; there were even, below the bridge, some boats not yet afloat. But as, besides the *Dart*, there are many brooks which issue from lateral combes, this whole basin is overflowed, when, after a great deal of snow has fallen on *Dartmoor* and the lower hills, a thaw comes on with much rain; and the water then rises to a great height near the bridge. In the course of the winter which followed this very autumn, Mr. Rocket wrote me word that the water had risen so considerably as to occasion, during a whole day, great apprehensions for the safety of the bridge. This effect is occasioned by the smallness of the distance between the two promontories of *Totness*, and by the piles of the bridge, which render the passage still narrower; so that the water, not running off fast enough, rises throughout the whole extent of the basin, filling the lower parts of all the combes; and the top of the bridge, as well as its piles, sustaining the pressure of this current, there is reason to apprehend that it may, in such a case, be broken down: however, when the water is at this height, its stream, divided by the piles, rushes through the arches in a long cascade, and is quickly reduced in the gulph to the level of the tides.

821. The promontory of the right bank is cut across in its upper part like that of *Dittisham*, but in a manner still more remarkable. We ascended it within the town, to the point where the latter extends into

the upper part of a *combe* descending on the southern side of the promontory. Thence we went down the slope of another *combe* following the northern side of the promontory; and towards the upper part of this last combe, is a mount, absolutely insulated, on which stands an ancient castle, commanding this part of the town. We ascended to the top of the castle, and between the battlements that surround it, we had a prospect of the whole circumjacent country, exhibiting the most manifest signs of the extraordinary catastrophes here undergone by the *strata*; one effect of which in this spot is very remarkable. At some distance from the castle, towards the north, there is a hill adjoining to this promontory, wherein is a quarry of the *slate* used for roofs; and on the same side of the opposite promontory is another quarry on the section of the *lime stone* strata.

822. We reimbarked at *Totness*, with the descending tide, at half past four, and reached *Dartmouth* at half past six. I accompanied Mr. Rocket to his house, where he had invited Mr. Newman to meet me: on hearing that it was my intention to observe the mouths of all the rivers between *Dartmouth* and *Plymouth*, Mr. Rocket was so good as to give me some letters of recommendation for that road, and Mr. Newman favoured me with one which I found of particular use at the part of the coast whither I proceeded from *Kingsbridge*, namely, *Salcomb*, situated on the western side of the gulph of *Portlemouth*, at the foot of a ridge of high hills bordering the

coast between that gulph and *Bigbury bay*, the cape of which, on the *Salcomb* side, is called the *Bolt-head*, and that on the side next *Bigbury bay*, the *Bolt tail*. But before I relate the sequel of my journey, I must stop for a moment, to compare the phenomena already described, with the idea formed by Mr. Playfair respecting the courses of rivers to the sea, whereof he gives the *Dart* as his first example; namely, that they have *hollowed out* the *vallies* through which they flow to the coast, and *cut* for themselves the *openings* by which they discharge their waters into the sea.

823. It may have been understood already, by the above description of the large basin wherein are collected the waters forming the *Dart*, before that river reaches *Totness*, that a great subsidence of the strata has here taken place; but this will appear still more clearly in the account of my next journey, in which I passed through this space in my way to *Dartmoor*; because I shall there point out the changes of situation produced in the different kinds of *strata* by the angular motions of the divided masses during their subsidence. But at *Totness* we find a *defile* at the issue of this basin; and of *defiles* Mr. Playfair says, (p. 105,) that nothing is to be seen in them "but the "gradual working of a stream, that once flowed as "high as the top of the ridge which it now so deeply "intersects, and has cut its course through the rock, "in the same way, and almost with the same instru-"ment, by which the lapidary divides a block of "marble or of granite." This operation ought to

be proved by the similarity of the *strata* on the opposite sides of these clefts; and such a proof is supposed by Mr. Playfair to exist; for he says, (p. 104,) that it is in *defiles* "that the *identity* of the *strata* on "both sides is most easily recognized, and remarked "at the same time with the greatest wonder." This, indeed, would *everywhere* be found, were the operation real; and besides, we should see, not merely by *the identity of the strata* themselves, but by that of their *inclination* and *direction*, that they had been mechanically cut, and not *broken*. But this is very rarely the case; and the idea can have no foundation, if there are even very numerous instances to the contrary; now one of these instances has been given in the *defile* at *Totness*, where the *strata* on one side are of *schistus*, and on the other, of *lime-stone*.

824. Again, had the same *instrument*, as Mr. Playfair supposes, continued its operation from *Totness* to the sea, it could only have *cut* a *valley* of a breadth nearly equal, throughout the whole of its length, to the *defile* above: whereas here we have seen wide spaces, followed by contractions; and at the same time the situation of the *strata* on the opposite sides shews that this whole valley, which happened, at the birth of the continents, to be below the level of the present sea, had been the effect of anterior catastrophes. With respect to that opening in the rocky hills bordering the coast, which gives to the neighbouring town the name of *Dartmouth*, and affords a passage to the waters discharged into the

gulph by the river eleven miles above, this is one of the places where it is also supposed by Mr. Playfair (p. 369,) that *rivers* formerly " ran upon a level as " high as the highest of the cliffs on the sea-shore." On this same level, indeed, the *Dart* ought to have flowed all the way from *Totness* to *Dartmouth*; for it should have cut its bed in the same manner along this whole extent till it had sunk it to the level of the sea. Now here we have another criterion, furnished by Mr. Playfair himself; who, being sensible that rivers cannot excavate below the level of the point at which their waters pass off, says, (p. 102,) in speaking of the junction of their branches with the principal streams, (and the case must be exactly the same with respect to the discharge of the streams into the sea,) that they have " such a nice *adjust-* " *ment* of their *declivities*, that none of them" arrive at this point, " either on too high or too low a level." How then could the *Dart*, after having produced so determined a declivity down to the level of the sea, towards which the breach made in the coast would have given it a free course, have laterally excavated the great basin of *Dartmouth*, within the ridge of hills bordering the sea shore? How could it have *sunk* this basin to a great depth *below* the level of the sea? while in this part of the gulph it flows with a *current* scarcely perceptible. Impossibilities here present themselves on all sides; and Mr. Playfair's observations must have been very superficial, since they have led him to form such an idea of the operations of the *Dart*, when he might have remarked that the sediments of the stream itself, and those of the tides, have, on the contrary, tended to fill up all these original cavities. This is what I have already very frequently shewn, and it will again appear with respect to all the rivers farther westward.

Oct. 6th. I set out in a chaise from *Dartmouth,* at eight in the morning for *Kingsbridge,* twelve miles distant. The road out of the town led me towards the *combe* the bottom of which, as I have already said, is called *Combe Mud;* then, ascending one of its sides, I came to a spot of a nature frequent among mountains and hills, and clearly manifesting that their intervals have not been excavated by running waters; I mean one of those elevated points, whence a *vale* descends in two contrary directions, or, as I may rather say, where meet the upper parts of two opposite *combes;* and where, consequently, no stream can ever have passed. The first of the *vales* of this kind to which I came has one of its slopes turned towards the upper part of the gulph of *Dartmouth,* where it terminates in a large creek; the other slope intersects the hills on the coast, and terminates in *Start bay.* As I proceeded in my way towards *Kingsbridge,* I crossed, among lower hills, several of these vales with opposite slopes, one being always directed towards the gulph of *Dartmouth,* and the other towards *Start bay:* afterwards I came into a large *combe,* which extends a considerable way inland, and in the upper part of which the village of *Blackauton* is situated.

825. I was now beyond the *combes* inclined towards the *gulph* of *Dartmouth;* from this point, I found them all directed towards the next *gulph* to the westward, which divides the wide promontory between *Start bay* and *Bigbury bay,* and has at its entrance *Portlemouth* to the east, and *Salcomb* to the west, I then crossed several other combes, the village of *Buckland tous-saints* being at the head of one of them; but they are all united at the bottom in a very low space, at the opening of which, towards the head of the gulph, is the small town of *Kingsbridge.* This place takes its name from a bridge, six miles distant from the sea, built in a part where the hills, below these united *combes,* approach each other: when I crossed it, a small brook only was flowing under it; and the tide being out, the space below it was full of mud, in which were lying here and there some boats and barges, waiting till the tide should rise to float them.

826. At *Kingsbridge* I had a recommendation from Mr. Rocket to MR. R. ILBERT PRIDEAUX, who gave me all the information which I desired. From him I learnt, that vessels of fifty tons still come up with the tide to *Kingsbridge,* but that, if the winds are not favourable, the water is in some parts so shallow, that they are aground during several successive ebbs; and that the gulph is every year more and more filled up: no river enters it; the largest stream is that at *Kingsbridge,* which is formed by the rivulets proceeding from the several *combes*

united above the town, and yet has no other name than the *Brook:* other rivulets issue from various combes terminating around the gulph. It is by the *sediments* of these little streams, when they overflow, that this original cavity is so far filled up; those sediments being retained here by the tides, which bring up the *sea-sand* in addition to them The lower parts of most of these combes at first formed creeks in the gulph, having been, at the birth of the continents, below the level of the sea; but the tides have tended to fill them up, as I shall presently shew.

827. Being anxious to arrive early at *Salcomb*, I set out from *Kingsbridge* at noon, following the gulph on the western side, by a road alternately ascending and descending, as it crosses the combes which intersect it. The tide being still at ebb, the lower parts of almost all the combes, and the borders of the gulph, were dry, as I saw from every hill. In particular, I remarked a large creek below *Charleton*, on the eastern bank, which was already very green; and I am informed that, since I was there, forty acres in this creek have been enclosed, and converted into good meadows, by Lord Boringdon, who has executed a much greater work of the same kind in the gulph of *Plymouth*, of which I shall speak in a future journey.

828. I arrived at *Salcomb* at half past one, and went immediately to present Mr. Newman's letter to Mr. Valentine, a custom-house officer at this

place, to whom it was addressed, and who shewed much disposition to oblige me. I first asked him for what reason the town on the opposite side of the gulph was called *Portlemouth*, since no river of a correspondent name entered the gulph; he said that it was only a village, and was probably thus named, as being the place nearest to the entrance of the gulph, its port having formerly been more considerable than at present. Having then told him that it was my intention to follow the top of the cliffs extending along the coast as far as *Bigbury bay*, that is to say, from the *Bolt-head* to the *Bolt-tail;* he replied, that I could do this only on foot, and that I should find such a walk extremely fatiguing; however, when he saw that I had determined to undertake it, he provided me with a very good guide, perfectly acquainted with the coast, and we set out together at two o'clock.

829. We went first towards the *Bolt-head*, it being on the *Salcomb* side; and in our way thither we crossed, near their upper extremities, two large combes, the lower parts of which originally formed creeks towards the entrance of the gulph on this side, but are now filled up, with sea-sand, and converted into meadows; and being near the open sea, the waves, as we have already seen to be the case in many other places, have at last raised a beach in front of these meadows, and thus secured them against future attacks. The rivulets, which are formed by the springs oozing out on the sides of the

combes, filtrate through this beach; and my guide told me, that, when a great deal of snow has fallen on the hill, and is suddenly melted, these rivulets, being much swelled, break through the beach, which however, when the floods have abated, is soon repaired by the waves. From the hills beyond these two *combes*, I expected to have ascended immediately to the *Bolt-head;* but before we reached that eminence, we came to a deep fracture, like that which I described §. 802, in the promontory between *Torbay* and *Babicomb bay;* this also descends to the level of the sea at the entrance of the gulph, and craggy points of the strata, irregularly broken, project on its sides.

830. We were obliged to go some way round, in order to pass the upper part of this fracture; and after another inflexion, we ascended the *Bolt-head,* a cape much higher than *Praule point,* which is on the opposite side of the entrance of the gulph. That circumstance is very contrary to the idea that this is an opening produced by a stream of water; and as, in fact, no *river* enters the gulph, this spot is not less contrary to another of Mr. Playfair's opinions, (p. 369,) viz: that *where there is no stream, there is no breach in the rocks* on the coasts. But besides, another example appears here of the difference often found between the *strata* on the opposite sides of the channels through which waters pass, whether inland defiles, or *breaches,* like this, *in the rocks on the coasts.* In crossing the hills on the eastern side of the gulph, I

had observed nothing but very soft *argillaceous schisti;* whereas the high hills extending from the *Bolt-head* to the *Bolt-tail* consist of an extremely hard *micaceous schistus,* containing abundance of quartz, as well in veins, as in masses dispersed through the strata, and even between them. These strata are much inclined inwards, and present their very irregular sections on the summit, where they form a multitude of sharp rocks of various sizes rising above the turf, with cavities in many of their intervals. I said, in § 799, that similar rocks of *lime-stone,* on the promontory between *Babicomb bay* and *Torbay,* gave it a resemblance to some of the summits of the *Jura*; now the *Bolt-head,* and the succeeding hills of the same nature, have an equal resemblance to some summits of the *Alps;* and this proceeds from the same general cause, namely, the angular motions of the strata. Shattered masses of these schisti form great projections in the front of the *Bolt-head* towards the sea; and one mass, having remained higher than the rest in the great subsidence which produced the new bed of the latter, rises above the water at some distance, and forms a large rock with dipping strata, called the *Mew-stone,* from the abundance of a kind of sea-fowl which make their nests in it.

831. Proceeding from hence along the brow of the rocks, as far as their disorder would permit, I saw the section of the *strata* which descend in a chaos towards the sea. Here also are several *combes,*

some of them very large, sloping downwards in the same direction. These cavities cannot have been hollowed out since the continent has existed; for they begin nearly from the top of an insulated ridge of hills, which border the coast, and descend on the land side as well as towards the sea; so that no current of water can ever have been formed on them. We were obliged to go a great way round, in order to pass by the upper part of one of these *combes*, which had a very rapid slope; it was covered with turf, like all the rest of the hill, and was studded, in the same manner, with the summits of the masses of strata dipping inwards. Beyond this combe, we ascended another cape, as high as the *Bolt-head*, and cut down precipitously both towards the sea and towards the combe, from a height of at least 500 feet. This cape, called the *Goat's head*, agrees with the alpine appearance which I have ascribed to this hill; and indeed I could have fancied myself in the *Alps*, when, on the points of these rocks, I saw goats, white and slender like the goats of those mountains; for no animal but this, which is naturally disposed to climb, can browse on the grass springing up on the projecting parts of these precipices.

832. From this elevated point, the hill descends towards the *Bolt-tail*, which I saw at a distance; but the numerous inflections of the intervening ground would have rendered it very tedious to proceed thither over the top of the hill, and my guide

told me that it was too late to attempt such a walk: however he proposed to conduct me to a part of the sea-shore, beyond the *Bolt-tail,* whence I should have a nearer view of it; and in this plan I acquiesced. We first crossed a *combe,* very wide and deep, the lower part of which is full of pointed rocks rising above the fern; but the upper part is cultivated, and the village of *Marlborough* stands in it. We passed this *combe* somewhat below the village; and after having crossed its western side, we came to the point of junction of two other *combes* diverging inland, one of which, very much interspersed with rocks towards the bottom, contains the village of *Boltbury,* and the other that of *Gampton,* whither we proceeded. These *combes,* when united, terminate at a certain height, on the north of the *Bolt-tail,* above *Hope-cove.* I could not then stop to examine the cove, but I returned thither the following day.

833. From *Gampton* we first went up to *Marlborough,* where begins another *combe,* which, diverging from the preceding, passes behind the hills of of the coast, and, following their foot, turns back to *Salcomb.* We arrived there at half past six, after a walk of eight miles, up and down hill the whole way. I went immediately to Mr. Valentine, to consult him about the continuation of my journey; as I intended to proceed the following day to the next gulph to the westward, which I wished to see, because its name denoted it to be the mouth of a *river,* viz.

the *Aven:* he told me that, in a chaise, it was impossible either to reach *Avenmouth*, without going a great way round, or to pass by *Hope cove*, which I was also desirous to observe; but that I might travel that road on horseback. I begged him therefore to engage for me two horses, with a guide, who would take charge of my portmanteau; this he was so good as to do, giving me likewise a letter, which I found very useful, to Mr. PHILIP PRIDEAUX at *Bigbury*, a village on the western shore of the gulph of *Avenmouth*.

Oct. 7th. I set out with my guide from *Salcomb* at half past nine in the morning; and again taking the road to *Marlborough*, we went down the *combe* to *Gampton*. Thence we saw the rocks descending gradually from the *Goat's head* to the *Bolt-tail*, an abrupt cape of no great height, which forms the eastern boundary of *Bigbury bay*.

834. This *combe* terminates below the village of *Gampton*, at a certan height above the level of the sea, in the recess called *Hope cove*, which is divided by a cape into two parts, namely, *North Hope*, and *South Hope*. Here I alighted, in order to walk down to the cove; my guide leading the horses round to a part of the shore a little farther on, whence, he said, I might ride along it for some way. I went down by the lower part of *Boltbury combe*, where a brook forms a cascade, and afterwards loses itself in a beach of a very interesting kind; its

gravel being composed of fragments of *schistus*, fallen from the cliffs after frosts, and repelled towards the coast by the waves. Among these fragments, I saw some of the most beautiful *micaceous schisti*, of brilliant red and green, and various intermediate shades, shewing the great variety of the strata whence they had been detached.

835. The tide being then out, and the sea very calm, and shallow in this part, I was able to distinguish its bottom under water to a great distance. Proceeding westward, I came to a sandy shore, on which dunes have been raised by the winds. But this sand must have been brought from a distance by the tides; for the bottom of the sea is here composed of the same *schisti* as the *Bolt-tail*, their *strata* dipping inwards, and forming ledges, so brilliant at that moment from the position of the sun, that they appeared like mother of pearl. Yet there is a hill, coming down to the shore and terminating in a cliff, which is composed of *strata* of *red pudding-stone*, like those of *Babicomb bay*. Thus the same *strata*, there seen to rest on the *lime-stone*, have here been formed on the *schisti;* and so, in a subsequent journey, I likewise found them to be near the *Ex*, above *Exeter*. We see then that, in this first part of *Bigbury bay*, within a certain distance from the *Bolt-tail*, the bed of the sea has been produced by the subsidence of the same *strata* which form these hills; and of this another monument will presently appear. But besides, these intermixtures,

mixtures, so frequently repeated, of *strata* of different kinds, externally at the same level, show to what strange catastrophes these strata were subjected at different periods, previously to the birth of the continents.

836. When I came to the spot where my guide was waiting for me I remounted my horse, and rode on along the strand. At *South Hewish* we passed the bottom of three successive *combes*, the lower parts of which were originally coves in the coast: the two other ones have been entirely filled up with sea-sand, brought in by the waves and the tides, and large horizontal meadows have been formed in them. But the water of the intermediate cove being deeper than that of the others, it had not been filled up when the strand was raised across its front; and thus the phenomenon of *Slapton lee*, described in § 811, has here been produced on a smaller scale; for the sea-water being excluded, that of the springs descending from the combes has converted this cove into a pool of fresh water, which discharges itself through the gravel; and as the rills issuing from these springs, when swelled by rains, deposite their sediments in its most remote part, their accumulation gradually displaces the water, and prolongs the meadow ground. My guide told me that, in very rainy seasons, a stream is formed which breaks through the beach, and that the meadows of all these three creeks are then inundated to a great extent, the water running off but slowly by the passages

opened in the beach; but that, when the inundation is over, all these breaches are soon repaired by the waves.

837. A little farther on, we saw in the sea the monument above alluded to of the catastrophe whereby its bed was produced; this consists of two masses of the same *schisti* that compose its bottom, which, in a part where it is deeper, have remained leaning against one another, nearly in an upright position; they are so high, that, though they touch each other at the top, there remains below, a space sufficient to permit a boat to sail between them, and my guide told me that the boatmen sometimes passed in this manner through the opening, to show their skill. These are called *Thurlestone rocks*, there being a village of that name near the coast.

838. We were here at but little distance from the gulph of *Avenmouth*, and *Bur isle*, which is near its entrance on the western side, was within our view; but this, at the moment when we observed it, was not an *island*, being united to the land by a beach then above water. After having passed before the third of the coves lately mentioned, we quitted the strand, and crossed a hill of considerable height; beyond which the village of *Buckland by Thurlestone* is situated in a very pleasant vale, its slopes being covered with a quantity of trees, though I had seen very few since I had quitted the immediate neighbourhood of *Dartmouth*. The hills here again con-

sist of *schitisti,* but of a very different kind from those which I had just passed, being argillaceous, and subject to decomposition by the air, and thus producing a soil proper for tillage. Though this combe is very large, no brook was then flowing there, nor is any formed in it, except in rainy seasons. Having crossed it to the foot of a ridge of high hills composing its opposite side, we ascended this ridge, till we came to a point where another combe opens on the west, and descends to the village of *Bentham,* situated on the borders of the gulph, or long æstuary, the opening of which to the sea is called *Avenmouth.*

839. The tide being still low when I came to the top of the hill commanding this æstuary, I saw its muddy bottom from *Bentham* up to *Aveton Giffard,* at the distance of four miles from the sea; the latter village is situated at the extremity of a vale covered with meadows; and in these I saw winding the river *Aven,* proceeding from *Dartmoor.* The *Aven* has entered this æstuary, ever since the origin of the continent; and here is seen the phenomenon which I have described in all the æstuaries hitherto mentioned; the sediments of the rivers and of the tides having been constantly tending to fill it up. As we descended towards *Bentham,* I saw rising above the grass on the sides of the combe a multitude of *schistose* rocks, which become harder towards the bottom of the slope, where they form a promontory advancing into the gulph, and much confining the

course of the tides. It is above this promontory that boats are kept for crossing the gulph. I left the horses at *Bentham*, but took over with me my guide, to carry my little baggage as far as *Bigbury*, at the distance of two miles, on the hill nearest to the sea. As we were on our passage, the boatman told me, that, during the highest tides, the salt water ascends as high as *Aveton Giffard*; but that, when the tides retire, their channel, almost down to *Bentham*, where it is deeper, is occupied only by the water of the little river. The hill of *schistus*, which rises on the *Bigbury* side of the gulph, is very high and steep; its extremity is cut down precipitouly to the sea; and *Bur isle* lies in the front of this cape.

840. Mr. Prideaux was luckily at home when I arrived at his house, and he was so good as to go down with me to the entrance of the gulph, in order to explain to me its nature. The sea being shallow without, the tides and the waves impel the sand from its bottom towards this entrance, where they have formed a high bar, which would entirely close it, were it not that the tides enter by a narrow passage, which they keep open as they descend with the water of the small river *Aven*, whence this place derives its name of *Avenmouth*. Within the gulph also, against the above mentioned promontory of *schistus*, is formed an accumulation of sand, which the winds raise up in dunes, and which, like the bar, leaves no passage but for the tides.

841. We went down on the outward bar, in sight of *Bur isle*, which is high and steep on the eastern side, whence it descends towards the west in a gentle slope covered with grass; and it is divided longitudinally by a fracture, down to the level of the sea. This island is inhabited only by fishermen, whose occupation it is to salt and barrel *pilchards*; vast quantities of those fish being taken, at a proper season, on this coast, as well as along that of *Cornwall*. In *Bur isle*, the fishery is carried on by a company to which Mr. Prideaux belonged; he therefore told me some particulars respecting it; but I had an opportunity of seeing it myself in *Cornwall* the following year. These fish when barrelled, are kept, till they are exported, in cellars dug in the rock of the island. Mr. Prideaux told me that the fishery of the preceding year had yielded 700 barrels. The way to this island is along the above mentioned bar of gravel, which is twice uncovered for six hours, during the four and twenty; namely, from about the middle of the descending tide, to that of the ascending.

842. Mr. Prideaux gave me also an account of the process of cultivation on these hills, the surface of which consists of decomposed *argillaceous schisti*. This process extends to a period of seven years. It is begun by ploughing the land, and burning the turf in small heaps, its ashes being then spread on the surface with lime; sea-sand is also used instead of the latter, if there be within a convenient distance,

any strand, where it is mixed with a sufficient quantity of broken shells; the abundance of which increases to a most astonishing degree on the coast to the westward and around *Cornwall.* The land is then sown the first year with wheat; the second and the third, with barley; and the latter crop leaves sufficient grass to be mown the fourth year; the three following, the land is in pasturage; but this becoming annually worse, the same succession of operations is recommenced at the expiration of the period.

843. The next gulph to the westward is called *Ermemouth*, because it receives the *Erme*, another small river proceeding also from *Dartmoor*. I had a letter of recommendation for *Muddicombe*, a village on the western bank of that gulph, which I purposed to reach the same evening; but Mr. Prideaux, seeing the strata of the tide, thought that I might find some difficulty in going directly thither; there is a ford across the gulph at low water; but for this it was now too late; and it not being in the way of any turnpike road, no boat is kept there for the passage of chaise or horses: he therefore advised me to go round the gulph by *Sequer's bridge*, and to spend the evening at that place, where I should find many interesting things to observe: he was so good as to lend me two horses, with a guide, and to give me a recommendation to Mr. PHILIPS, an acquaintance of his, whom he requested to lodge me for the night, and to procure for me another guide, with horses, for my

journey

journey the next day to *Plymouth*, taking *Muddicombe* in my way.

844. I set out at five o'clock for *Sequer's bridge*, which was at the distance of five miles. I had still to ascend for a considerable way before I reached the top of this ridge of hills; it is interspersed with many small eminences, shewing the state of the schistose strata, which here do not appear on the surface, it being cultivated in the manner just described; but I observed their section on the sides of the road down the long descent to *Sequer's bridge*, and I saw them inclining inwards in great disorder. In going down this side of the hill, I perceived that it terminated in a low valley, which I supposed to contain the course of the *Erme;* but, when I came to the bottom, I found there only a rivulet. Here I met with another of the numerous instances of the difference of the strata on the opposite sides of vallies. I had just descended a hill composed of *schistus;* and on the other side of the rivulet I ascended a lower hill consisting of strata of *lime-stone:* in passing over the latter, I saw in several places quarries where this stone is dug out, and burnt for lime on the spot, chiefly to be used as dressing for the lands.

845. It was near seven when I arrived at *Sequer's bridge*, where Mr. Philips gave me a very obliging reception; and when I had explained to him what were the objects of my research, he was so good as to walk out with me immediately, in order to give me a pre-

a previous idea of what I should have to observe more particularly the following day. The small river *Erme* arrives at *Sequer's bridge* through large meadows evidently formed on the materials which have filled up the head of the gulph; for they are absolutely horizontal, and are intersected with drains for the purpose of carrying off the waters during floods. This is not a simple bridge, but more properly a causeway, with a large arch over the *Erme* itself, and several smaller ones over the ditches in the meadows, which extend five miles below the bridge; and though the channel preserved through these by the river is not wide, the tides ascend almost as high as the bridge; so that, for the security of the meadows, it has been necessary to border this channel with embankments for a considerable way. Nevertheless, the sea has still a share in the inundations here, because the high tides prevent the running off of the land-waters. It is not above a century since these meadows, being sufficiently raised by the sediments of the tides and of the river to be no longer covered but by the spring-tides, were embanked, in order that their grass might be mown for hay. Thus on all coasts are found places, where the progress of the operations of natural causes on our continents, since their birth, is marked by dates which afford a proof of their small antiquity.

846. The ridge of the *calcareous* hills arrives here from the N. E., after having passed by the villages of *Ugborough* and *Shilstone;* it is then continued in

a south-westerly direction, always between hills of *schistus*, till it arrives at *Plymouth:* in some parts, it is double; in others, on the contrary, it is interrupted; for instance, the hill over which I had passed in my way to *Sequer's bridge* terminates, as a promontory, in the gulph of *Ermemouth;* where its foot is now surrounded with meadows, because the valley that I had crossed between the *schisti* and the *lime-stone* becomes much wider in its lower part, which, having been, at the birth of the continents, below the level of the sea, formed at first a creek in the gulph, but has been since filled up, and converted into meadows; however, either the water was there deeper than in other parts, or the sediments of the *Erme*, during its inundations, have arrived there in less abundance; for it is only within a few years that these meadows have been embanked.

Oct. 8*th.* Mr. Philips took me in the morning to see a quarry of his own, which is in a small and nearly insulated hill behind his house. There I saw the section of the *strata* of a *lime-stone*, much resembling the most ancient *secondary* lime-stones of the *Alps*, which contain but very few *marine bodies;* I observed none in this stone. These *strata* are so much broken and disordered, that they can be distinguished only by the parts where the masses are easily separable; and there they appear to incline inwards.

847. Mr. Philips was so good as to procure two horses and a guide to go with me to *Muddicombe*, five miles distant, and thence to *Plymouth*. I set out at half past eight in the morning for the former place, where I had a recommendation from Mr. Short, to Mr. Lane, the clergyman of the parish, whom I fortunately found at home; and he obligingly accompanied me to the nominal mouth of the *Erme*. This is a place very similar to *Avenmouth;* being the entrance of an original gulph, between two capes, of which the cape advancing on the eastern side, called *Beacon point*, is a great deal higher than that on the western, where we then were. The entrance of this gulph also has been almost entirely closed; and here the cause common to all slips of land formed on the coasts, and before the entrances of gulphs, is manifestly seen; namely, a *submarine bar* of strata left at a higher level, at the time of the *subsidence* of the present bed of the sea. The tide was low; and on the outer side of this slip of land, which is within the gulph, I saw, at the level of the surface of the water, a ledge of schisti, commencing on the eastern side, and extending so nearly across the gulph, that no passage is left but for small vessels on the western side; and all the outer coast is bordered with so many similar rocks, that it is very dangerous for the ships sailing in the bay, if a violent wind from the sea suddenly rises, which does not permit them to keep off shore.

848. The slip of land formed within this gulph is very wide: we went down on it, as it belongs to the *Muddicombe* side: its outer part consists only of pure sea-sand, which the winds have raised in dunes; and the tide being low, no water appeared within, but that of the small river: Mr. Lane shewed me the part where it was then fordable, and where I should have crossed it the day before, if Mr. Prideaux had not supposed the tide to have already entered the gulph: but, as he had judged, I was very far from regretting that I had taken such a circuit, on account of the interesting objects which I had found at *Sequer's bridge.* The sediments of the *Erme* have been mostly retained by the tides in the upper part of the gulph; so that its lower part is filled up almost entirely by sea-sand; and as soon as the tide has retreated, the whole space, as I learnt from Mr. Lane, is firm enough to be trotted over on horseback. This is because no sensible quantity arrives here of the earthy particles brought down by the *river*, for which reason, though frequent attempts have been made to form oyster-beds in this gulph, it has been found impossible, notwithstanding there are some in the next gulph to the westward, that of the *Yealm*, where the oysters are so fine, that they are carried to a considerable distance; for there, the sediments of the river are very abundantly mingled with the sea-sand.

849. Great numbers of salmon are caught in the estuary of the *Erme*, where they follow the tide across

the meadows, in quest of the fresh water; they are taken in three different ways, as Mr. Lane explained to me, according to the breadth or situation of the different parts of the channel. In the narrowest passages is placed a large osier basket, in the form of a funnel, with its wider part turned towards the mouth of the æstuary, whence the salmon ascend; on entering this basket, they are not stopped by the narrow part, the osiers there being loose; but when they attempt to return down with the tide, the points of the osiers oppose an obstacle to them, and while they are trying to find a way through these, they are enclosed, and taken with a net. In some wider passages, when the tide has already gone back to a certain point, a purse-net is stretched across, in which the salmon are caught in their return to the sea. Lastly, in passages of a different kind, an osier hurdle, rising nearly to the height of the middle tide, is fixed at the bottom of the channel; the salmon pass over this, when they ascend with the flood; but staying above, as long as there is sufficient water, either to feed or to spawn on the bottom, they return too late to be able to pass again over the hurdle; and here also they are taken with a net.

850. Between this gulph of the *Erme*, and that of the rivers *Plym* and *Tamer*, lies the gulph of the *Yealm*, which I mentioned above, and which likewise it had been my intention to cross; but Mr. Lane dissuaded me from attempting this, the road being very little frequented, and boats of a proper size to carry

over horses being seldom in the way: he therefore advised me rather to go up to the head of the gulph, and cross the river by the bridge at *Yealmpton;* whence, he told me, it would not be worth my while to make so great an angle as to follow the other side of the gulph down to *Yealmmouth,* because I should there find only, what I had already observed in all the gulphs on this coast, that it was in great part filled up, which, indeed, I might see at *Yealmpton;* so that my best way would be to go from the latter place to *Oriston,* and thence to cross over to *Plymouth.* He was so good as to press me to defer my departure till the next day, because he expected to dinner an old acquaintance of mine, whom I should really have been very glad to meet, MR. BASTARD, one of the members for this county. But considering how much ground I still had to go over before the end of the season proper for such excursions, I was sensible that the year was too far advanced to allow me to devote any time to my own pleasure; thus I could only thank Mr. Lane for so kind an invitation, without being able to profit by it.

851. I set out therefore from *Muddicombe* for *Oriston,* at the distance of ten miles, going first to *Yealmpton* over the hills. I never travelled on a road which ascended and descended more continually, these hills having no regularity in their arrangement; sometimes they are insulated, sometimes they unite and form *combes;* thus shewing, like all the others in this part of the country, that inward disorder of the

strata, which is concealed on the higher parts by the loose soil either in tillage or in pasture, but discovered on the slopes where the sections appear. From the hills nearest to the course of the *Yealm* and its gulph, I could see that the latter, as Mr. Lane had told me, is in great part filled up: towards the head, it is divided into three branches, each of which receives a stream arriving from a different valley, the lowest parts of all these vallies having originally been *æstuaries*. At *Yealmpton*, I passed the principal stream, bearing the name of the *Yealm*, not on a simple bridge, but on a causeway with several arches, across meadows formed on the mud with which the æstuary has been filled up. This causeway is at the distance of four miles from the sea; the meadows extend considerably lower; and the tide being out, the rest of the space, as I had seen from the hills, was now entirely occupied with mud. It is there that the above-mentioned oyster-beds lie, because of the sediments deposited in that part, during the inundations of the three streams arriving there from a distance. After passing the *Yealmpton* meadows, I crossed the widest of the promontories dividing the head of the gulph, on which is situated Mr. Bastard's seat at *Kitley*; I then passed, on a bridge, the second of the streams that enter the gulph; and I saw the lower part of this æstuary likewise occupied by meadows.

852. We are now approaching a point where all the phenomena will be of particular importance; I mean that of the confluence of the two rivers *Plym*

and *Tamer*, whence they flow on united to the sea; a spot to which Mr. Playfair expressly refers in support of his hypothesis, that there was once a "time "when the *rivers* ran upon a level as *high* as the "highest of the cliffs on the sea-shore;" for he particularly speaks of these rivers, as having "flowed on "the level of, *Mount Edgecombe* or of *Staten* "*heights*," hills which border *Plymouth sound* in the part nearest the sea. I wish that, before Mr. Playfair had formed his hypothesis, he had employed in an attentive examination of this spot some portion of the time which I thought it necessary to devote to that purpose. In this case, he would surely have found it essential first to study the genera and species of the strata around this gulph, with their respective situations, in order to judge whether there was any necessity for attributing its existence to the united actions of the waters of the land and of the sea; and next, to observe attentively the courses of the two rivers, with the view of discovering whether they had really excavated their bed. To this investigation I gave all the time which it required; and with regard to the first of these objects, some interesting phenomena presented themselves between *Kitley* and *Oriston*. From *Muddicombe* to some way beyond the first of these places, I had seen only hills composed of soft argillaceous schisti; but, as I approached *Oriston*, I first observed those very hard quartzeous schisti, described, in §. 839, as lying under the argillaceous, while here they are on the surface; and then I again met with the ridge of the lime-stone hills, which coming from beyond *Sequer's bridge*, is cut off by the gulph at *Oriston*, and afterwards again appears at the extremity of the promontory of *Plymouth;* where, having crossed over from *Oriston*, I arrived at three o'clock.

853. Having considered *Plymouth* as the central point of many very important observations, I had taken all the precautions which I thought might be necessary to secure myself against meeting with any obstacle there. Commodore Sir HARRY NEALE had given me a letter for Captain FANSHAWE, commissioner of the Dockyard; and from the Bishop of *Exeter* I had received one for Admiral YOUNG, the port-admiral, and another for MR. GANDY, the clergyman of one of the parishes of *Plymouth.* On my arrival, I immediately called on the latter, who told me that, besides the Bishop's recommendation, he considered me as having a claim upon him, on account of his acquaintance with my brother at *Exeter* many years before; he therefore received me very cordially, and both he and his sons were of great assistance to me: I explained to him the nature of the observations which I wished to make; and he immediately did me a most essential service, by carrying me with him to call on Captain MARTIN of the Royal Navy, from whom I gained a first general idea of the manner in which the *Plym* and the *Tamer* are connected with the gulph of *Plymouth;* and a topographical plan of the latter, given to me by

this officer, proved extremely useful to me in my observations.

Oct. 9th. I employed the morning in taking my first survey of the place; after which, Mr. Gandy accompanied me to the town of *Dock*, explaining to me such objects as presented themselves in the way. Having delivered my letters to Admiral Young and Commissioner Fanshawe, I informed them likewise what it was that I wished to learn respecting the phenomena of the gulph, which they were so good as to describe to me with all requisite particulars. It is then from the exact information thus obtained from persons necessarily well acquainted with the spot, that I shall first give a general description of the *gulph* of *Plymouth;* after which I shall relate my own detailed observations on the gulph itself, and on the circumjacent country.

854. I shall begin by mentioning a fact of great importance with respect to the question, whether the two *rivers* have *excavated* this space, cutting their own channels by *erosion* down to the sea. This fact is, that *Plymouth sound*, which is the entrance of the gulph from the sea, is not its *deepest* part, it being here, at the utmost, eight fathom deep, and in many places not more than four or five; while in the branch called the *Hamoaze*, into which the *Tamer* enters, the depth is in some parts seventeen fathom. This difference results from a cause, well known, and very contrary to Mr. Playfair's idea; namely, that,

instead of *excavating*, the waters of the *land* and of the *sea* have tended, and do still tend, to *fill up* this *original cavity*. I have already shewn in §. 824, when speaking of the gulph of the *Dart*, that rivers cannot possibly excavate their beds below the level of the sea; because, as soon as their surface is lowered to this level, they cease to have any action on their bottom, since they no longer retain any declivity. How, therefore, can the little *Tamer* have excavated an immense space, no less than seventeen fathom below this level? That the reverse is the case, namely, that the river has continually tended to fill up this space, will appear in the course of my observations.

855. The sea, likewise, is continually tending to fill up the gulph. It is a fact very well known, that, when the former is agitated without, the tide, which enters by the *sound*, is not only *troubled*, but *muddy*; now, during the interval of rest, before the turning of the tide, the greater part of this mud is deposited in the widest part of the gulph, up to the entrance of the æstuary of the *Hamoaze*, the middle of which, being situated between the influx of the sea on one side, and that of the *Tamer* on the other, has remained the deepest part of the gulph; the men of war being there moored to chains fixed on the bottom. If, when the tide is ascending, the direction of the winds is such as to impel and accumulate the water against the exterior coast on the east, it produces the astonishing phenomenon called the *Bore*; for it rushes

suddenly in with a great noise, like a kind of moving hill, and is very dangerous, not only to boats, but even to small ships lying at anchor, which it sometimes upsets.

856. It is by the current of the descending tides, formed within the *Hamoaze*, and impelling the sediments of the *Tamer* into the creeks and to the borders of this long arm of the gulph, that a channel is kept open for ships; the creeks into which this mud is thrown are the extremities of lateral vales, originally below the level of the sea. They might all be now converted into meadows, if their entrance were closed against the high tides, which has been done in some places; but the Admiralty put a stop to this process, because, were the volume of the retiring water to be thus diminished its current would become too weak to reach the bottom in the middle part of the *Hamoaze*. The case is the same with the *Catwater*, another arm of the gulph, which is entered by the *Plym*; but this is of little importance, and the enclosure of such spaces in it as can be converted into meadows is not prohibited, as will appear from my observations. The *Hamoaze* is separated from the *Catwater* by a promontory, which advances into the gulph, and on the extremity of which is built the town of *Plymouth*.

857. From the above general account of the effect of the waters in this gulph, it very evidently appears that its excavation cannot have been their work;

which will be confirmed by the description of the beds of both the rivers before they arrive in it. But besides this, the true cause of its existence, namely, the *subsidence* of the *strata*, is rendered manifest by phenomena the most characteristic, as well of that event itself, as of the still greater *catastrophes* with which it was attended. With respect to the subsidence, it is shewn by large masses of the sunken *strata* remaining higher than the rest, and forming *islands*, together with a multitude of *rocks* level with the surface of the water. Two of these elevated masses of considerable size are within the gulph, where they are surrounded with low rocks, as is the case with all its shores; one of them is *St. Nicholas's island*, near the middle of the sound; the other is *Mount Batton*, at the entrance of the *Catwater*, which has been united with the coast by an isthmus composed of sand and gravel, a direct proof that it could not have been separated thence by the action of the waters. A proof of the same kind is afforded by many insulated rocks under the water; which have been so far from suffering any erosion, that they have detained the sand brought into the gulph, and have thus occasioned the formation of sand-banks. With respect to monuments of the various catastrophes of the *strata* which accompanied the subsidence of the large mass, it will appear by my description of the hills surrounding the gulph, that, within a space of inconsiderable extent, these hills, together with the rocks which rise to the surface of the water at their foot, consist, some of *lime-stone*, some of *schistus*, and some of *porphyry*. This, I should think, might suffice to convince Mr. Playfair that he observed this place too superficially; but it was of such importance to leave no room for doubt on the subject, that I devoted several days to the investigation of the details, of which I shall now give an account.

857. *a.* I have said that, the day after my arrival, Mr. Gandy was so good as to accompany me to the town of *Dock*; and the following were the observations which I made in the excursion. Between *Plymouth* and that town, another has been built within these few years, on a hill between two creeks communicating with the *Hamoaze*, and both filled up. A house called *Stone-house* has given its name to this third town; which has been so much increased, as well as that of *Dock*, that, on account of the multitude of carriages passing between them and *Plymouth* it has been necessary to soften the slopes towards the first creek; and this being too wide to be crossed by a simple bridge, a causeway has been made over it. Now for this purpose, as Mr. Gandy told me, it was requisite first to bring here an immense quantity of large blocks of stone, and to continue for a long time to load these with fresh blocks, till their own weight had sunk them, through the mud, down to the bottom; notwithstanding which he made me remark that the causeway, since it has been built, has sunk in the middle, although, in order to prevent the softening of the

mud by the influx of the tides, the entrance of the creek has been closed by an embankment, and the space within has thus been converted into pastures. The next creek, being narrower, is crossed by a bridge: it has not been enclosed like the former, because, at its most remote extremity, there is a *tide-mill*, of the kind elsewhere described. The tide being out when we passed over this bridge, the whole creek was dry; I saw in it only the rill formed by that portion of the water of the high tide which had been retained in the mill-pond. When I came to the dock-yard, Commissioner Fanshawe, who was so good as to shew me several parts of it, acquainted me with a very interesting circumstance. The extremity of the promontory separating the *Catwater*, or mouth of the *Plym*, from the *Hamoaze*, into which the *Tamer* enters, consists of *lime-stone*, and is the end of the ridge of hills of that kind coming down from beyond *Sequer's bridge* to *Oriston*, where it is interrupted by the *Catwater*: the rest of the promontory above, and the succeeding hills, are of *schistus*. In describing my road the following day, I shall shew, that, on the *Catwater* side, these two kinds of strata are separated by a *combe*; but they are again united on the *Hamoaze* side, where the dock-yard is situated. Commissioner Fanshawe here led me to a basin, hollowed out, some years ago, in the foot of the hill, down to the level of low water, in which is kept the timber for the masts; the water being retained in it by a sluice. Now in sinking this basin, when the superficial rubbish had been cleared away, and the *strata* beneath it were discovered, those of the *schisti*, much inclined, were found resting against those of the *lime-stone*: the line of their junction runs across the basin, but the muddiness of the water would not allow me to see it; and on the outside, it is still concealed by the rubbish. All these *strata* are inclined towards the space now occupied by the *gulph*, where those of *lime-stone*, manifestly formed on the *schisti*, have sunk, no parts of them remaining above the level of the water but *St. Nicholas's island*, and an insulated mount on the other side of the gulph, which I shall have occasion to describe.

Oct. 10*th*. I took an one-horse chaise with a guide, for the purpose of observing the rivers *Plym* and *Tamer* above the places where they arrive at the level of the sea, the former entering the *Catwater*, and the latter, the *Hamoaze*.

858. I set out from *Plymouth* at eleven in the morning; and taking at first the road along the top of the promontory, leading to *Tavistock*, (which stands at the foot of *Dartmoor*,) I came to the place called *Nackershole bridge*, whence begin two large *combes*, one sloping down on the west, towards the *Hamoaze*, and the other on the east, towards the *Catwater*; I descended the latter of these. No streams but *rivulets* either flow, or ever can have flowed, in the *combes*, as I have already explained; and if there be even so much as a rivulet, it proceeds from the springs which issue from their sides, where

sections of the *strata* have been formed by the *subsidence* that has produced the cavity. In the *combe* that I descended, there was a rivulet, which afterwards crossed a meadow formed on the soil filling up the lower part, originally a *creek* in the *Catwater*. I saw men then at work on a causeway intended to pass in front of this creek and another nearer *Plymouth*, serving as a road from that place to the bridge across the *Plym*, without passing over the hill, and at the same time as an embankment to secure the meadows of both the creeks against the influx of the tides.

859. I saw *schisti* on both the sides of the *combe* which I descended; but that nearer *Plymouth* has them only on the side forming its separation from the preceding, the opposite side being composed of *limestone*, which extends on to the extremity of the promontory. These two kinds of strata are here separated by the whole space of the combe; but towards its top they unite, their junction, as I have already said, appearing in the dock-yard, on the other side of the promontory. The *schisti* beginning here, which are frequently associated with strata of *gneiss*, and extend northward towards *Dartmoor*, and westward into *Cornwall*, are those that contain *veins* of tin and of copper. It is by their *subsidence* that the valley of the *Plym* and the *Catwater* have been formed; and the following is a proof of this subsidence. The bottom of this whole arm of the gulph is covered with the sediments of the tides and of the *Plym*, to

a very great depth. Now it having appeared, from some indications on the sides, that a *vein* passed across this æstuary, the bottom was explored in search of it. My guide shewed me a circular dam constructed near the middle of the space, which, as the tide was out, I saw covered with mud; and he gave me this explanation of its use. This dam, resembling a wall round the mouth of a well, was founded on a basis of schistus, and built up in such a manner as to prevent the high tides from entering the enclosed space, in which the adventurers sunk, to find the vein; it was actually found, and for some time followed; but it has been since abandoned, not proving rich enough to pay the expense of working it. This part of the vein must, it is evident, have subsided with the strata.

860. The head of this æstuary, or extremity of the valley through which the *Plym* arrives, consists of meadows to a great extent: thirty years ago, they were still inundated by the high tides; and it is only since that time that they have been protected by an embankment. Now here a judgement may be formed of this *river*, supposed by Mr. Playfair to have contributed to the excavation of the *gulph* of *Plymouth* after having flowed at the height of *Mount Edgecombe*, which borders the coast: formerly it was forded at low water below the meadows; but a turnpike road now passing that way from *Plymouth* to *Totness* and *Exeter*, a bridge has been built there called *New bridge*, situated near one of the entrances

of Lord BORRINGDON's park; on going into which, I beheld a large vale, originally forming a branch of the æstuary of the *Catwater*, and communicating with it a little below the spot where the bridge is now placed; but the whole space, having been enclosed with an embankment, is now converted into very good meadow land. Since the time when I made these observations, Lord Borringdon has enclosed a large creek in the *Catwater*, of which I shall have occasion to speak in a subsequent journey.

861. Having returned over the bridge of the *Plym*, I proceeded westward, in order to observe the *Tamer;* and passing by the village of *Jump*, I arrived on the hills which separate the two rivers, and went on some way in the *Tavistock* road. My guide told me, that the small river *Tavy*, according to the state of the tide, might be crossed by two different roads; one leading to a point where this stream is fordable at low water, near its junction with the *Tamer;* the other to a higher part of its course, where there is a bridge over it called *Denham bridge;* but he said that, before we determined between these roads, we might see the state of the tide by going into the park at *Marystow*, towards which we therefore proceeded.

862. The summit of these hills is of great extent towards the east; and in passing along it, I observed a phenomenon, very common on high grounds, but proper to be mentioned here, on account of its relation

tion to the question whether *rivers* have excavated the *vallies* wherein we now see them flow. In the upper part of these hills, are some inflexions affording a passage to *brooks*, which fall into the *Tamer*, and are as considerable as many others that run in very deep vallies; why then have not *vallies* been hollowed out by them? They have flowed as long a time as the *Tavy*, and the *Tamer*, and all the small streams which we now see flowing in *vallies;* that is to say, ever since the birth of the continents. This is therefore a strong proof, in addition to so many others as I shall continue to adduce, that running waters have only followed the original intersections of the ground.

863. As I was here approaching the large eminences of *Dartmoor*, I again met with the phenomenon which I described (§. 788,) on *Furzleigh hill*, near *Bovey Tracey*. Though the hills consist of *schistus* and *gneiss*, I began to observe *blocks* of *granite* lying on them; and it will be seen that these blocks are as unequally scattered here, as they are in *Mecklenburg* and *Holstein*, the countries described in the preceding volume. In many places, I saw the ground broken up in quest of *veins;* and my guide shewed me a spot at a small distance, where one had been found and followed for some time, but had afterwards been abandoned, like that in the *Catwater*, because the product did not equal the expense. I shall describe, in the sequel, the mode of carrying on this search. We entered the park of *Marystow*, and

went to the edge of some high ground, whence I saw two æstuaries of equal size, forming continuations of the *Hamoaze;* the nearest of these was the lower part of a *combe*, from which only a *brook* proceeded; in the other flowed the *Tavy*, arriving from *Dartmoor*. These æstuaries, in the upper part between the ridges of the hills where the sediments of the tides are chiefly deposited, were covered with grass, and still dry; but the tide had already reached the lower part, in which they unite, and along which the road passes; we were therefore obliged to return to the high road, in order to go round by *Denham bridge*.

864. This road crosses the highest part of the hills, which is covered with heath, except some spaces forming downs; and yet I saw on it a quantity of blocks of *quartz*, *gneiss*, and *granite*. After a long descent, at first gradual, but at last very steep, we came to the bridge, built in a part where the hills, approaching each other, leave under it a very narrow chasm, into which the river descends with great rapidity; below this it flows through meadows formed within its *æstuary*, at present bordered with an embankment to exclude the high tides. There is no road this way down to the *Tamer;* therefore, after crossing the bridge, we passed several ridges of hills, on which, in various places, I saw the summit formed by the section of the *schistose strata* inclined towards the valley of the *Tamer*, and rising here and there in rocks. Proceeding thus, we reached the

upper part of a *combe* descending towards that river; but it was too steep for the chaise, which I therefore left above, and went down on foot. This brought me into the valley of the *Tamer*, about a mile below *New bridge*, by which a new communication has been formed between *Devonshire* and *Cornwall*: this river, flowing from north to south, divides the two counties almost from sea to sea; as will be seen in my next journey.

865. We have now reached the banks of the second of those *rivers* which are supposed by Mr. Playfair to have formerly flowed at a level, as high as *Mount Edgecombe*, and to have gradually excavated their own *vallies*, as well as the *gulph* of *Plymouth*: let us see how far the state of things corresponds with this idea. I first directed my attention to the two sides of the *valley*, which, if the *Tamer* had cut it by erosion, in the same manner that *a saw divides a block of marble or granite*, ought to be symmetrical. Instead of this, I saw the hills above mentioned, which form the eastern side of the valley, and through an interval of which the *Tavy* arrives, cut down almost abruptly, and every where full of *schistose* rocks, projecting among the trees that grow on all the little terraces interrupting this precipice: while the opposite side to which I had crossed over, presented a slope, covered from top to bottom, with an immense quantity of *blocks of granite*. Here, as is the case in *Holstein*, where there is no mountain, either of granite, or of any

stony kind, these *blocks* are hewn for various purposes, the river affording such easy means of conveyance for them. I saw here a quay, on which stonecutters were employed in hewing them into many different forms; such as columns and pilasters, some of ten feet in length, parallelopipeds for the base of houses, troughs, stones to place under the stands of corn-stacks, and several others: in a word, the *granite* is worked here as in a quarry; and the quantity of the blocks on this slope is so great, that it will be very long before they can be exhausted. Now what is the nature of the mass of the hill, on which these *granitic blocks* are scattered in such prodigious abundance? This is manifested by a mine opened some years since at its foot, and already carried on nearly fifty fathom, in pursuit of a vein containing copper and tin, like most of those in *Cornwall.* So far as the miners had yet proceeded, the thickness of this vein had not in any part exceeded three inches; but they were in hopes of finding it in time become thicker, as often happens. However, it had been necessary to open the gallery to a sufficient width to allow the miners to advance, and consequently to cut away a great deal of the stone in which the vein is contained: this stone had been thrown out in heaps at the entrance of the mine, and I saw that it was *gneiss.* Such then is the material of which the mass of the hill consists, although the surface is covered with so great a quantity of *blocks* of *granite.*

866. This is the first great example of a geological phenomenon, which, in my journey into *Cornwall*, will occupy much of our attention under a variety of aspects, when compared with the hypothesis of the Huttonian theory respecting *granite*; but here I shall consider it only as connected with the cause of the disorder observed in our *mineral strata*; a phenomenon which, in that theory, is assigned to *elevation*, our *continents* being there supposed to have risen out of the bosom of the sea, while at the same time, the formation of their vallies by erosion, and the dissemination of *blocks of stone* over their surface, are attributed to the action of *running waters* on them since they have existed. We here find a hill covered with *blocks* of *granite*, the transportation of which it is no less impossible to ascribe to the waters, than that of the immense quantities of similar blocks scattered over the sandy hills in the north of *Germany*, as I have shown in the preceding volume. And with respect to the idea that vallies have been excavated by running waters, we have seen that all the phenomena of the *strata*, already described in this country, prove both *vallies* and *gulphs* to have been the effects of *subsidences*. Now in many places, according to the circumstances by which these *subsidences* have been accompanied, the expansible fluids, violently compressed within, have thrown out fragments of the *inferior strata*. Hence, as I have shown by numerous examples in *Mecklenburg* and *Holstein*, these explosions having taken in particular spots, there are, at little distance from

each other, certain parts which are covered with *blocks*, and others where there are none. This is also the case here; for having followed the river to a point where the hills recede on both sides, I saw a hill without any blocks, on the same side with that whereon they were scattered in such prodigious abundance: a contrast of which I shall give new instances on the eminences of *Dartmoor*, and which cannot be explained by any other cause than the above.

867. It is in this part, where the valley widens, that the *Tamer* enters its *æstuary*, the *Hamoaze*: had Mr. Playfair come hither to observe it, the notion that this river formerly flowed at a level so high as that of *Mount Edgecombe* could never have occurred to him; for here, as well as at the head of all other *æstuaries*, is found a direct proof, that, since the continents have existed, no change can have happened in the *level*, either of the *sea*, or of the *mouths* of the *rivers*. The *Tamer* has prolonged its course through meadows which are absolutely *horizontal*, being formed on the part filled up of this extremity of the æstuary. These meadows have been embanked for two purposes; first, to secure them from the return of the high tides; and next, to make advantage of those tides, by confining their course within a walled channel, and thus leading them into a basin, which is hollowed out at the extremity of the course of the *Tavy*, and bordered by the above mentioned quay, the water being retained

in it by a sluice, or *wear*, like that already described at *Exeter*. Barges ascend into the basin, and descend from it, by the sluice, but only at high water; for the size of the stream of the *Tamer*, even after its junction with that of the *Tavy*, is very small, as will presently appear. These barges bring up, from *Plymouth*, coal and such other things as are wanted in this part of the country, and carry down hewn granite, corn, wood, and the ore produced by the mine.

868. On all the hills which surround this spot, are impressed marks of a *subsidence*, as well in the abrupt sections of the *strata* of *schistus* on the left bank, and their inclination on the opposite side of the valley, as in the contraction of the latter below this very wide part. The tide having now retreated, the whole space below the meadows was beginning to be dry. Seeing a house near, I entered it, in order to inquire what was the size of the *river*, when the tide was quite out, and it flowed alone: the people there told me, that, except in very rainy seasons, their children crossed it on foot, only taking off their stockings; and that the sediments deposited by the tides, and by the river, during its inundations, were gradually raising the soil on both sides of the channel which the waters preserve for themselves a considerable way down the *Hamoaze*. Here then, at the mouth of the *Tamer*, we find the same phenomena as at that of the *Plym*. By the *mouths* of rivers ought certainly to be understood, in geological language,

the points where they arrive at the level of the sea, since it is there that they mingle their waters with those of the tides, as is the case with the *Dart* at *Totness*, and the *Ex* at *Exeter*; in a word, with all the streams which I have already described, and shall describe in future, when they enter into *æstuaries* at the extremity of the inclined soils that lead them down to the level of the sea. Hence it is impossible to maintain, with the smallest shadow of reason, that, since the continents have existed, any one of these *rivers* has flowed at a *higher level* than that at which it flows at present. It would therefore be superfluous to apply directly to this question such phenomena as I continued to observe in this country, manifesting the great dislocations of the *strata* during the *angular motions* of their masses divided by *subsidence*; the catastrophes thus imprinted on all the hills being the evident causes of *vallies* and of *gulphs*. It was about six o'clock when I returned to the place where I had left my chaise, at the distance of two miles and an half from *Tavistock*. I crossed several hills separated by combes, before I came to the course of the *Tavy* near that town, which takes its name from the river. At this place I passed the night.

Oct. 11*th*. I set out from *Tavistock*, at half past eight in the morning, on my return to *Plymouth*. I first crossed the *Tavy*, by a bridge at the bottom of the town, in a part where it flows very rapidly among blocks of *granite*. On this subject I shall again remark,

mark, that the masses of stone which are found on some parts of the beds of rivers issuing from mountainous regions, as here from *Dartmoor*, could not, but in consequence of very superficial observations, have been considered as brought down by those rivers. For if, after we have observed these *blocks* in some parts of the bed of a river, we follow its course, we come to parts where there are none, and again to others, where we find them in great abundance; a case of which many examples will appear in these travels, and which could not occur, if these masses had been brought down by the stream. And farther, it is very evident from the aspect of the hills bordering the vallies, where also these *blocks* abound in some parts much more than in others, that we are to ascribe their being found on the beds of rivers to the same cause which has disseminated them on the heights. A little below the place where the *Tavy* thus flows among blocks, its course has been barred, for the purpose of raising its waters, and leading a part of them, or even the whole in times of drought, by a channel which is cut on one side of the valley, and carries them to some mills.

869. I next crossed some low hills of *schistus* intermixed with *grey wacke*, or *dun-stone*, and then ascended the high ground covered with turf, called *Roborough downs*, over which I had passed the preceding day. Some time before I came to the gate of *Marystow* park, I saw at a little distance, in an inflection of the upper part of the hill, an insulated rock,

rock; and going towards this, I found it to be of considerable length and height, and to consist of *strata* of *gneiss*, inclined towards the road from which I had perceived it; and farther on, in the same direction with the length of this rock, I saw a succession of points of the same stone rising above the turf, others being also scattered near these: this is the only part of the hill where any rocks appear; and they are here, because this mass of *strata* sunk less than the rest in their common catastrophe, when they became inclined towards that part where the greatest subsidence taking place produced the *valley* of the *Tamer*, and the *Hamoaze*: and another symptom of this catastrophe is, that, in every cavity or inflexion lower than the upper part of the hill, the soil is marshy, and springs issue from it; which shews that, below the loose soil, there are *sections* of the *strata*.

870. On this road, I again saw the ground opened in many places, for the discovery of *veins*; and I learnt from my guide, on this occasion, what I found afterwards in *Cornwall*, to be the general custom of the country. The veins belong to the lord of the manor in which they are found; but it is seldom the lord himself who explores them, this being undertaken by miners who are called *adventurers*, and who, understanding the exterior appearances which indicate *veins*, obtain his permission to dig in search of them at their own expense, and often on condition that they shall fill up the cavities and level the surface, if they find nothing.

It

If they actually find a *vein*, the next condition is, that they shall be at the whole expense of working it, and give to the lord of the manor a certain portion of the pure ore which they shall take out of the mine. This portion is called the *dish*; it is commonly a tenth; but, if the vein is unpromising, less is accepted, while, if it is expected to prove very productive, more is demanded. Lastly, if the object appears of sufficient importance to require the whole machinery of pumps and engines, and to employ a great number of miners, these expenses being too heavy for the first *adventurers*, they associate others with them, dividing the mine into shares, which are bought and sold, and of which a part is often taken by the lord of the manor himself, who thus becomes an *adventurer* also.

871. I reached *Plymouth* at noon; and calling on Mr. Gandy, to give him an account of my excursion, I projected another for the following day, when I proposed to take a boat to visit a part of the borders of the gulph, going afterwards to *Mount Edgecombe*, and thence following the hill which borders the exterior coast as far as the cape of *Rame head*, at the entrance of the *Sound*. On my mentioning this plan, Mr. Gandy's eldest son, a clergyman likewise, very obligingly offered to accompany me; and one of his brothers, still very young, but full of ardour, desired to be also of the party.

Oct. 12th. We took a boat at ten o'clock in the port of *Plymouth,* which is situated in a cove at the extremity of the promontory of *lime-stone* advancing into the gulph. This port is sheltered from the waves by two piers, and between these lies its entrance.

872. The extremity of this promontory, as well on its summit as in its section towards the gulph, evidently appears to owe its form entirely to the catastrophes of the *strata.* Between *Plymouth cove,* and the creek on the west called *Mill-bay,* there is, on the borders of the gulph, a mount which is united with the land behind, but rises considerably above it, and cannot have been cut into this shape by any exterior cause. The citadel of *Plymouth* stands on the eastern extremity of this mount, which is called the *Hoa,* and is steep on the side towards the gulph, where it is bordered with rocks rising to the surface of the water: these were uncovered when we were on the spot, and we saw them present the upper sections of the *lime-stone strata,* which, in the *subsidence* that produced the gulph, remained higher than the rest, dipping towards the vacant space: in the *Elementary treatise,* I have given instances of the same phenomenon, around the *lakes* of the *Alps* and of the *Jura.* Between *Mill bay,* and the creek preceding the docks on the west, rise two other mounts nearly insulated: in the interval betwixt these, on the side next the gulph, is a space called *Fire-stone bay;* and here also, along the shore, there are low rocks in

the water, surrounded in part with the mud which is tending to fill up this little bay. The eminence on the west is called *Devil's point;* and hence proceeding to the promontory of the dockyard, we arrived at a cape called *Old Gun-wharf*, where we left our boat, and crossed the gulph in a passage-boat; landing at a point on which is an obelisk belonging to the grounds at *Mount Edgecombe.*

873. This is the deepest part of the gulph; because, being confined between the *Devil's point* and the cape of *Mount Edgecombe*, the current of the tides, which descends from the *Hamoaze* and its creeks, being more rapid in this part, called *Crimble passage*, carries down with it the sand brought up by the ascending tides; thus, for a considerable way, the depth continues to be seventeen fathom. The southern side of the gulph, on which we were now arrived, demanded an attentive observation, because of Mr. Playfair's idea that the *Tamer* formerly flowed over *Mount Edgecombe;* I was therefore particularly struck at finding here one of the most evident proofs that the *gulph* had been produced by the catastrophes of the strata, before this river had begun to flow. A mass of the same *lime-stone strata*, which, on the other side, compose the *Devil's point*, form on this side a mount, completely insulated, and abruptly cut down towards the gulph, its *strata* descending in the opposite direction, and plunging under other soils: it is on the summit of this mount that the obelisk is placed. This is the only mass of the *lime-stone*

strata on the southern side; while on the northern, all the capes which I have just described, together with *St. Nicholas's island* in the middle of the gulph, are composed of this stone; and it will be seen, by the mixture of the strata on this southern side, which separates the gulph from the open sea, in the part called *Witsand bay*, to what astonishing catastrophes they were subjected at the formation of the *gulph*, and even of the present *bed* of the *sea;* both having evidently been effects of *subsidence.*

873. *a.* Under the mount of the obelisk, there is a very wide beach, extending to some distance eastward; on this there is an inn, where we took a chaise, in order to go over the heights to *Rame head.* We ascended the hill, and followed the enclosure of Lord MOUNT EDGECOMBE's park along the brow of this hill, which is considerably higher than any of the other grounds bordering the *Hamoaze* on the western side. Mr. Gandy informed me that the word *Oaze*, which is pecular to this gulph, but might seem to originate in the Egyptian *Oasis*, here signifies a grassy space, alternately covered and abandoned by the tides. Spaces of this kind extend along all the borders of the *Hamoaze* and its creeks, to above *Saltash*, where its depth in the middle is still eight or nine fathom; but beyond this, up to the head of the æstuary, the depth diminishes, the *oazes* approach each other, and at last are united, leaving only the narrow channel already mentioned for the *Tamer;* this being the part where the sediments of the river,

during floods, have been chiefly accumulated. The first of the creeks of the *Hamoaze* on the western side, above the narrow part by *Crimble passage*, is an *oaze* which extends nearly half way across the promontory separating the *gulph* from *Witsand bay*; and we saw the greatest part of it dry. This is called *Milbrook creek*, from a brook entering its upper extremity, and raised by a dam, for the use of a mill. A long slip of land, very low, and covered with turf, at the extremity of which is the village of *South down*, separates *Milbrook creek* from the following one on the same side, called *St. John's oaze*, and also *St. John's lake*, because it contains a space resembling a lake. Another promontory, which has at its extremity a village named *Tor point*, separates *St. John's oaze* from another creek farther up in the *Hamoaze*. Both sides of this gulph are equally intersected by creeks of the same kind, formed by the lower parts of the *combes* sloping down to its borders. In the *Catwater* likewise the word *Oaze* is used in the same sense.

874. This description of the inner part of the *gulph* of *Plymouth*, considered with respect to the effects of the waters of the *land* and of the *sea*, manifests a very important circumstance, which Mr. Playfair's hypothesis tends to set aside. If these waters had indeed excavated the *gulph*, together with the *combes* and *vallies* coming down to it, the ages that have elapsed since the birth of the continents must be reckoned by thousands; and this is in fact what the system which he defends would require. But this

operation is chimerical: in studying the situation of the *strata*, we perceive, at the first glance, that their catastrophes have produced these intersections of the surface; and with regard to the effects of the *waters* of the land and of the sea, it is evident that, since the continent has existed, those waters neither have had, nor ever can have, any other effect than to *fill up* all these *cavities*. Now this affords us a *chronometer* which perfectly agrees with all others belonging to the coasts. At the extremity of the *Hamoaze* and of the *Catwater*, in all their creeks, and on their borders, we see the whole effect of these operations, the rate of their *progress*, and their *causes*; and every observer, who shall fix his attention on these circumstances, must find an impossibility of supposing them to have *commenced* at the distance of a very great number of ages.

875. We continued to follow the enclosure of the park of *Mount Edgecombe*, till we came to the highest part of the hill, whence we turned to the east, towards the village of *Maker*. I remarked, as we passed along, that the exterior soil consisted of a coarse red sand, the nature of which I did not comprehend; but having quitted the chaise, in order to descend, by a very steep path, to *Cawsand bay* within the *Sound*, I saw strata of red porphyry abruptly cut off towards the latter; and by the decomposition of this porphyry the sand is produced. On the border of *Cawsand bay* are two villages, near each other, yet situated in two different counties. The path led us down to the

first of these, called *Kingsand*, or *Kingston*, which belongs, with *Maker* and *Mount Edgecombe*, to *Devonshire;* while, excepting this insulated spot, the rest of the promontory, terminated by *Rame head* to the south, is in *Cornwall*, together with all the western shore of the *Hamoaze;* that æstuary, and the *Tamer* which flows into it on the north, forming as I have said, the boundary of the two counties nearly from north to south. The southern part of *Cawsand bay* belongs likewise to *Cornwall*, as well as the village of *Cawsand*, whence the bay derives its name. A vale, with a brook flowing through it, terminates here, and forms the division of the counties in the bay, wherein is found a phenomenon, which, at the same time that it will render evident how little foundation there is for the supposition that *running waters* have excavated the vallies, will shew to what astonishing revolutions the *strata* were subjected, at the epoch when the gulph was formed by their *subsidence*.

876. I have said that, in descending to *Kingsand*, I saw the *strata* of a red *porphyry* abruptly cut off towards the gulph. This first part of the coast is bordered by large rocks of this porphyry, extending even below the water, into which their *strata* dip. In front of the vale separating the two combes, there are no rocks, either on the coast or in the sea; but they begin again beyond this, in front of the village of *Cawsand;* where, at so small a distance from the former, I was not a little surprized to find rocks of quartzeous micaceous *schistus*, the *strata* of which

dip into the sea, like those of the *porphyry* rocks. Here then we have the same kind of monument of the formation of the *gulph* by *subsidence*, as we see in the *strata* of *lime-stone*, on the opposite side; for these masses of *strata* clearly point out, by their inclination, the place where those have sunk which were originally united with them. But besides, what strange *angular motions* and dislocations must have been undergone by these *strata*, once assuredly placed one over another! For here, within a space of little extent, (the breadth, merely, of the gulph,) we find *strata* of *lime-stone*, of argillaceous and micaceous *schisti*, and of *porphyry*, all brought by these catastrophes to the same level.

877. In the *vale* whence issues the brook at the bottom of which the *porphyry* meets the *schistus*, I could not discern the line of their junction, because of the small gravel covering the bed of the brook; but I was struck with the beauty of the *schistus*, in the part washed by it on the eastern side; it was like that of the *Bolt-tail*, (§§ 834, and 835,) shining with the most vivid green wherever it reflected the light. I have said that there are no rocks in the water before the extremity of this vale, where the sea is very deep; however the waves bring up from the bottom some small gravel, forming a beach very interesting on account of the variety and beauty of its colours, especially in the parts washed by the waves; it is composed of several species of *primordial stones*, the *strata* of which do not externally appear, but

must have been broken and triturated below the level of the present sea, at the formation of its bed.

878. Our chaise had waited for us on the hill beyond this bay; to meet it, we ascended on the *schistose* side, and arrived at the village of *Rame church*, which stands on an elevated spot. Here we again left the chaise, on account of a long and rapid descent down to a part of the promontory commanded also on the southern side by its extremity called *Rame head.* This part is so narrow, that, when we stood in the middle of its breadth, we saw beneath us the *Sound* on the north, and *Witsand bay* on the south. The prospect on the latter side is very interesting, on account not only of its beauty and extent, but of its geological importance. Advancing as far as was possible along the edge of the isthmus on that side, we saw the whole coast, which is very abrupt, dissected by the projections of the masses of strata dipping into the sea, where they form, by their planes rising into pyramids, the same effect as is produced by the *Needles* of primordial strata around *Mont Blanc*. The sea is very deep before this part of the promontory, which forms the eastern side of *Witsand bay*; hence, though rough at that time, it was very clear; and this permitted us to follow with our eyes, to a great distance, the summits of the sunken micaceous *schisti* forming rocks under the water: while, in the western part of the same bay, where the rocky coast continues, we saw along its foot a very wide sandy

strand, extending, as Mr. Gandy told me, beneath the water, with very little declivity. This characterizes the *subsidence* which produced the present bed of the sea, a subsidence more considerable in the eastern part of the bay, than farther to the westward; and it is, at the same time, very contrary to Mr. Playfair's idea, (p. 370,) that when the *Tamer* and the *Plym* flowed, as he supposes at the height of *Mount Edgecombe*, the coast advanced *many miles* beyond its present line. How could the sea have *excavated below its own level*, so much as it ought to have done on the eastern side of this bay to have acquired there such a depth? How can it be supposed on the contrary, to have demolished the coast farther to the westward, when it has raised a very wide strand against that coast? How could effects so opposite to each other have been produced within so narrow a space?

879. From this low isthmus, we ascended the *Rame head*, an eminence which is cut down abruptly at the extremity of the promontory, and of which the grassy slope towards the isthmus is so rapid, that, were it not for the edges of the *schistose strata* rising above the turf, it would be nearly impossible to climb up to an ancient castle placed on the summit. Rocks are formed also along the slope by these dipping *strata*; on examining which, I saw them, in the lower part, descending towards the extremity of the promontory; higher up, near the summit, they become vertical; and in the abrupt side of this

extremity, they have the contrary inclination, and rise towards the sea. By these various inclinations of the *strata* in their subsidence, when the bed of the sea was formed, their different species have been brought to view at the surface: it has been seen that they are *quartzeous* and *micaceous* in *Cawsand bay*; but by degrees they assume an *argillaceous* nature, and at *Rame head* is found the *slate* proper for roof.

880. From this elevated point, the *Eddy-stone* is seen in the sea to the southward, at the distance of twelve miles from the shore. This rock is a mass of the *sunken strata* which has remained at a higher level than the rest, like the rocks near the coasts, and the larger masses forming *islands*, as already described. There have been light-houses on the *Eddy-stone* for a great length of time; but they were formerly in danger of being thrown down by storms, and those who had the care of them were thus exposed to great risks, until Mr. SMEATON, an engineer, and also a distinguished experimental philosopher, constructed the very solid edifice at present standing there. I shall have occasion, in a future journey, to mention whence the lime-stone was taken to make lime for the mortar of this building; which will be found another very interesting geological fact.

881. Here ended my observations on the gulph of *Plymouth* and its vicinity, as I remarked nothing

farther on our return. I could wish that as I followed Mr. Playfair hither expressly to examine very attentively the ideas which he had formed here, so he, with the same view, would revisit this spot, and those that I shall describe on the same coast in a future journey; for it is only by verifications of this kind that truth can be ascertained. As I intended to quit *Plymouth* early the next morning, I took leave that evening of the persons from whom I had obtained so much information and assistance, and particularly of the family of Mr. Gandy whose friendly reception of me I shall always recollect with gratitude; however I left them with the hope of seeing them again the following year.

Oct. 13*th.* I set out from *Plymouth* at six in the morning for *Exeter*, the distance being forty-three miles. I found the road very interesting, as it crosses, at a distance from the sea, the rivers of which I have described the mouths; but I shall defer speaking of it more particularly, until, in my next year's travels, I shall have visited *Dartmoor*, where all these rivers have their origin.

882. After leaving *Plymouth*, I crossed the *Plym* on the bridge already mentioned, situated at the extremity of its æstuary, the *Catwater.* I next passed the small river *Yealm* by *Mill-bridge*; and then, at *Ivybridge*, I crossed the *Erme*, a river equally small, there presenting a picturesque scene, as it breaks and foams among large *blocks* of

granite, with which all these low hills, though consisting of *schistus* and *dun-stone*, are covered. After this, I passed, at *Brent*, the little river *Aven;* then, in different vales, two branches of the *Dart;* and lastly, arriving in the extensive low space already mentioned, called *Bovey heath*, leading to *Chudleigh*, I there crossed two branches of the *Teign*. All these rivers rise in *Dartmoor*, as I shall hereafter more fully describe.

883. I have said that *Chudleigh rock*, which forms part of a calcareous hill extending southwards, here advances near the hills of *schistus*; and it will be seen in my second journey in this county, that the latter hills are continued above *Exeter*. But it is not by this phenomenon alone, that the disorder of the *strata* is here manifested: before I reached *Exeter*, I crossed the *Haldon hills*, the high parts of which consist of *strata* of *sand* and *sand-stone* containing marine bodies; and these are on both sides bordered by low hills composed of the *red-strata*. The *Haldon hills*, though separated from those of *Blackdown* by the large valley of *Exeter*, and several ridges of hills with *red strata*, present the same phenomenon which Mr. Playfair observed on the *Blackdown hills*, namely, a great quantity of scattered *flints*; but as that gentleman's hypothesis with regard to these flints occupied me, on account of its great geological importance, in several subsequent journeys, I shall not yet enter on that subject.

884. When I came to the brow of the *Haldon hills*, commanding a view of *Exeter* and the surrounding scenery, I was much struck with the beauty of the prospect, to which, indeed, the season of the year contributed. The soil of the fields newly ploughed being of a bright red, it formed an agreeable contrast with the lively green of those interspersed among them, where the corn had already sprung up: all the compartments of this kind of chequer-work were bordered with trees in hedge-rows, which, as well as some scattered woods, displayed all the rich tints of autumn; and this fine scene was farther embellished by the beauty of the meadows and scattered villages, bordering the great æstuary of the *Ex* down to *Exmouth*, where it opens to the sea. I arrived at *Exeter* at five o'clock, whence the next day I proceeded into *Somersetshire*.

FIRST JOURNEY THROUGH SOMERSETSHIRE.

885. Mr. Playfair, when he refers to the mouths of the rivers on the southern coast of *Devonshire* and *Cornwall*, speaks also of the mouths of those on the northern coast of the peninsula as no less favourable to his hypothesis: the observation of the latter had therefore formed a part of my plan; but as the season was now so far advanced, I deferred travelling into *Cornwall* till the following year, and concluded my present journey by visiting, for the first time, the coast of *Somersetshire;* doubly interesting, because, while it is, on one side, a continuation of the northern coast of *Devonshire*, it forms, on the other, a part of that *western* coast of *England*, which I had already observed at *Bristol*, and which it was become essential to compare with the *eastern* coast, on account of what Mr. Playfair had said respecting some of the phenomena of the latter in *Suffolk* and *Lincolnshire*, considered by him as produced by local *subsidences* followed by *elevations;* an hypothesis which has formed the first object of my examination in the present volume.

Oct. 14*th.* I set out early from *Exeter*, that I might have a little time the same day at *Bridgewater*, where I intended to stop. Between *Honiton* and *Taunton*,

Taunton, I passed over the eastern extremity of the *Blackdown hills* by the same road as was taken by Mr. Playfair; who, having observed there a great quantity of *flints*, formed respecting them the hypothesis which I have already mentioned, and which is given at large in p. 373 of his work. I now took only a superficial view, as he probably had done, of the objects within sight from the road; but this was sufficient to determine me to examine these hills with the particular attention which I actually bestowed on them in my subsequent travels: for the present, I continued my journey without stopping, till I arrived at *Bridgewater* at one o'clock.

886. The acquaintance which I had formed at *Dartmouth* with Mr. Rocket here procured me that of his friend Mr. Jenkins, the clergyman of this town, and mayor for the present year; and I was indebted, both to him, and to the gentlemen to whom he introduced me, for the most essential services. From Mr. Jenkins I received the first information respecting the soils of this very remarkable county, where I began my observations the same evening; but before I enter on them, I shall give a geneal idea of this coast.

887. The town of *Bridgewater*, at present five miles from the *sea*, stands in a part which was formerly occupied by the latter; there having been here an original *bay* of great extent, divided by *Polden hill*, a long promontory of small *calcareous*

hills, so low in the part communicating with the land, that it wanted but little of being an *island.* The northern division of the *bay* extended from this promontory to the *Mendip hills,* which form a high ridge, *calcareous* also, but of a nature very different from *Polden hill* ; the latter consisting of strata of the *lyas* already described, while the *Mendip hills* are composed of *strata* of various kinds of *marble.* These latter hills, which advance from the interior part of the country, come down to the sea-shore, where they bounded the original *bay* on the northern side; its southern limit having been formed by the soils descending from the foot of the *Quantock hills.*

888. Such then, I say, as all the phenomena will be seen to prove, and traditional monuments to testify, was originally the state of this rich and extensive part of *Somersetshire* ; it formed a large *bay,* in which, besides the long *promontory* above mentioned, there were several *islands.* Now the whole of this wide space is at present filled up, and all the *islands,* as well as the promontory, are surrounded by new lands, so that what is now called the *bay* of *Bridgewater* scarcely deserves that name; whereas the original *bay* formed a large recess in the coast. These *new lands* are called *Marshes,* a name differing only in orthography from that given to the lands of the same kind on the coasts of *Holstein* and *Sleswigh,* which I described in the preceding volume: at first, undoubtedly, they were, in both countries,

nothing more than marshes, though at present they are become excellent meadows: they are called also *Fens*, on some parts of the coast; and when they are covered with peat, the name of *Moors* is given to them here as well as in *Germany*. Three small rivers, which originally discharged themselves into the *bay*, have prolonged their course through these *marshes*; the *Axe* on the north, now flowing along the foot of the *Mendip hills*; the *Brue*, more to the south; and the *Parrot*, on the course of which *Bridgewater* is situated.

889. In many parts of the inner border of these meadows, it is difficult to distinguish by the eye the exact boundary of the lands thus added to the original shores of the *bay*; for the latter descend with a very gentle slope, along the lower part of which the meadows have extended themselves; and it is from these soils that the peat, wherewith they are for the most part covered, has slidden down on the *marshes*: it had even slidden some way under the level of the sea, before this space was filled up by the sediments of the land-waters and of the tides; as will appear in the sequel. But in digging down below the turf, the *original soil* is easily distinguished, as it consists of the *red strata* which compose the low hills encompassing the original bay. The greater the distance from this inner border of the *marshes*, the greater is the depth of their characteristic soil; under which lies sea-sand, mixed with shells of the same kind as are now found on the outer strand, indicating

a time when the sand driven by the waves into the bay was still uncovered by the sediments of the rivers: this sand, mixed with shells, had formed here also *sand-banks,* which are now embraced by these sediments; some of them even rising so nearly to the surface, that the turf immediately rests on them; as will be seen in the account of my next journey in this county.

890. When we observe the immense extent of these meadows, all on a modern soil, we cannot at first, but be surprized at the mass of the sediments which must have been brought hither to fill up this space. But the case is the same here as it is with respect to all *new lands* on the sea-shore, where the sea without is shallow, and *sand-banks* have been formed in it, as has been already described near *Bristol.* The waves, and even the tides when the sea is agitated, cast up on the coast a great deal of sand, of which, almost alone, these *new grounds* are for some way composed: and here again, as in other places, the winds raising the sand on the exterior strand, form it into *dunes.* As for the abundance of the sediments of the land-waters, this no longer appears surprizing, when we consider (as I have already had occasion elsewhere to point out) that, at the birth of the continents some time elapsed before the loose soil of the surface of the hills was bound by vegetation; as the seeds of plants having been successively spread, from the summits of the mountains which had been islands in the ancient sea, over

the circumjacent countries, their propagation must necessarily have proceeded very slowly. Thus at first the rains washed down great quantities of earthy particles; besides which, the streams formed in the vales, while clearing and straitening their channels, must also have carried along with them abundance of the same materials. The *Parrot*, having a longer course than the two other rivers, and arriving at the sea during floods with greater power, cast up on its sides the sand which was tending to be accumulated on the coast, and thus produced a curved slip of land, designated in the maps by the name of *Stert point*, and resembling one already described on the coast of *Suffolk;* this slip is curved, because, while, on one hand, the course of the river impelling the sand, accumulated it at a greater distance than along the rest of the coast, on the other hand, this accumulation forced the stream itself to bend; and within the creek thus formed lies a small island. Some years ago, this slip of land was cut through by a storm, and its extremity is now reduced to an island, still bearing the name of *Stert point.*

891. From this general description of the *marshes* or *fens* of *Somersetshire*, on the *western* coast of *England*, it evidently appears that they resemble those of *Lincolnshire* on the *eastern* coast, which Mr. Playfair, without having himself observed them, considered as a particular phenomenon, produced by a local *elevation*, with a subsidence following it: I shall

I shall now shew, in the details, that the same circumstances which suggested to him this idea, have here been produced by known causes.

892. The very evening of my arrival, as soon as I had obtained sufficient directions from MR. JENKINS, I followed the course of the *Parrot* below *Bridgewater*, walking along its left bank. Though this town is five miles from the sea, the great tides peculiar to *St. George's channel* are here very perceptible, the difference between high and low water being under the bridge as much as twenty feet: and the tides themselves extend above *Langport*, as I have had occasion to observe in other journeys. Now the extent to which the tides ascend in the channels of the three rivers certainly indicates that this whole space was originally sea; and that the soil now filling it up has been formed by the sediments of these rivers and the sea-sand; which, indeed, is the opinion of the inhabitants of the country.

893. I followed the course of the *Parrot* almost down to the sea, walking on the embankment, in order to observe the influence of the tides. Two-masted vessels ascend here as high as the bridge, but only with the tide; for, as it was then low water, I saw these vessels lying on the mud, moored on both sides of the channel; smaller vessels were moored only on one side; and those still smaller merely lay on the mud. Hence it is evident that this channel is filling up, the sediments of the ascending tides not being

totally carried down by the retreating tides and the common current of the river: when I was there, the latter was flowing alone in the channel, and was very small.

894. As I went along on the embankment, I saw, by two different effects, how sensible is the progress of this operation of filling up by the tides. Mr. Playfair, (p. 432,) thinking to refute Mr. KIRWAN with respect to the deposites of the tides, objects to him theoretically, that, since it is the same mass of water which moves towards the coast during six hours, and is also six hours in its retreat, there cannot be any difference in its effects. But I have already shewn, in another place, that theory alone might have sufficed to make him understand the contrary, if he had examined in what manner this same mass moves, in the two opposite cases. When the tide rises towards the coast, the whole mass moves together, and exercises its action on the bottom, agitating and raising the mud, which it carries towards the coast, and deposites there during the interval between the flood and the ebb; but when it retreats, it flows back at the surface only, beginning from the shore, and exercising scarcely any action on the bottom. I proved this by observation at the end of my travels in the preceding volume, and I shall now shew that the effect of the tides in the *Parrot* concurs in the same proof. When this great extent of meadows was embanked for the purpose of security againſt the high tides, and the embankments were carried along the

channels preserved for themselves by the rivers in these new grounds, there were in that of the *Parret* large spaces forming pools, round which it was necessary to carry the embankments; but after this had been done, the sediments of the tides, thus confined within the channels, not only raised the bottom, but filled up the pools; and since then, in order at once to gain so much more new land, and to increase the rapidity of the descending tides by narrowing their course, these spaces have been enclosed by new embankments. But another circumstance will more immediately shew how quickly the sediments are deposited here. At a certain distance from the sea, this argillaceous soil is mingled with a sufficient quantity of sea-sand to be proper for bricks, which are burnt in some parts adjacent to the channel. Now when excavations for this purpose have been made of a certain depth and extent, new ones are begun, and the old are filled up by a very simple process: a sluice is placed in the embankment near them; this remains open while the tide rises, and is shut when it begins to descend; the water, enclosed within, deposites its mud, and is afterwards allowed to run off when the tide is quite out: and in this manner these excavations are filled up in the course of a few years. Of this process I shall have an opportunity of giving another example.

895. Having returned to Mr. Jenkins, and described to him what I had observed, in order to be certain that I was not mistaken on any point, I made

some inquiries of him relative to the objects that might interest me in the remainder of my journey, which I meant to resume the next day. He pressed me very obligingly to prolong my stay at *Bridgewater*, telling me that I should find many things worthy of observation in the neighbourhood, out of the common road: of this I did not doubt; but I preferred returning hither another year: the rains had already begun, and the season was so far advanced, that I was anxious to reach home as soon as I could, without losing the opportunity of making a few useful observations in my way, where, in particular, I wished to see that phenomenon of the *Mendip hills*, called the *Chedder cliffs*, of which I had heard an interesting account. After considering therefore in what manner I might pursue my journey to the greatest advantage, the following plan was arranged. Mr. Jenkins kept a school, in which he had a French assistant, M. PAINS, a man extremely well informed and very obliging, who offered to accompany me some part of my way. A friend of Mr. Jenkins's, MR. WILLIAM ANSTICE, had at that time the superintendence of works very favourable to my views; it having been undertaken to cut new channels for the *Brue* and the *Axe*, in order to straiten their course, and terminate it with very strong sluices, towards the sea; which would afford me an opportunity of seeing the interior part of these soils. Mr. W. Anstice, who commonly resides at *Bridgewater*, had then taken a house at *Uphill*, situated at the extremity of the *Mendip hills* nearest to the sea, in order to be more within reach of these works: Mr. Jenkins was so good as to introduce me to this gentleman's brother, Mr. Robert Anstice, who gave me a letter to him; and Mr. Poole, who was present, informed me of some particulars relative to the history of the marsh lands.

Oct. 15*th.* M. Pains having undertaken to shew me the road to *Uphill*, we set out at nine in the morning in an one-horse chaise. The causeway across the *marshes* is very firm and smooth, being made with lime stone taken out of the neighbouring hills, which differs in its nature, as do the hills that happen to be nearest. In our way to the *Brue*, we passed over the extremity of *Polden hill*; and thence I saw a great extent of the new lands formed before this promontory of the ancient bay. Here appears a phenomenon very characteristic of great *dislocations* in the strata, accompanying their *subsidence*. This promontory which originally intersected the bay, though proceeding from beneath the *red strata* of the low hills surrounding the *marshes*, is composed of *lyas*, a very distinct class of *lime-stone* strata, prevailing, in various parts, over all this country: while the *Mendip hills* on the north, as I have already said, are composed of strata of different *marbles*; and the *Quantock hills* on the south, which I observed in a subsequent journey, consist of *schistus* and *grey wacke*.

896. From the end of *Polden hill*, the road passes on to *Highbridge* near the mouth of the *Brue*, where I saw one of those changes which are brought on by the *progress* of the *amelioration* of the soil. This part of the *marsh* near the sea, being mixed with a great deal of sea-sand, forms very good arable ground; but for that purpose it has required to be better secured against the inundations of the sea and of the land-waters. It is on this account that the new channel has been cut for the *Brue*, in a strait line, wider and deeper than its natural channel, and with high banks; the part nearest the sea has been strongly walled, and in this part have been placed two of those sluices with flying gates, which form an angle when they are closed. The outer sluice opens towards the sea; and when the tide ascends, its gates are shut by the pressure of the water. The inner sluice is kept open, as long as the river, and the ditches by which the waters of the marsh are carried off, require a discharge at low water; but, in times of drought, it is closed, in order to keep the water at a certain height in the ditches, that the soil may not crack. I have already said that this is also the practice in the *marshes* of *Holstein* and *Sleswigh*.

897. This new channel for the *Brue* being opened, nothing more has been necessary for filling up the old one, than to turn its sluice the contrary way; the former use of this sluice had been to let out the land-waters during the ebb; but now it serves to admit those of the sea during the flow, and to oppose

their descent till they have deposited their sediments. We went on the embankment of this channel, and I was surprized to see how much it had been filled up within four or five years. Hence we descended on a very wide strand, extending beyond the enclosed land towards the sea, and still continuing to increase in breadth. The sediments of the rivers being detained within the meadows, this strand consists entirely of *sea-sand*, and the winds have raised *dunes* on its inner part. Here then we have again the same proof which I have pointed out in many similar places, as well on the coasts of *England*, as on those of *Sleswigh*, that none of the materials carried off by rivers, from the *continents* to the *sea*, ever quit the coasts, to pass down to the depths of the ocean; though such a supposition forms the very foundation of the Huttonian theory. All the materials which the *Brue*, the *Axe*, and the *Parrot*, have detached from the continent since they first began to flow, have remained in the ancient *bay*, and have there even received the addition of the *sand* of the sea itself.

898. From *Highbridge* we went on to *Hob's boat*, where we crossed the *Axe* by a ferry; but it had been undertaken to make a great change in the course of this river also, as I shall presently mention. In our road, we passed near one of the *islands* of the ancient bay, that of *Brent*, which rises to a great height; I shall describe it in a future journey. It was near *Bleydon* that the new channel for the *Axe* was carrying on in a strait line, across the wide

meanders formed by that river in the *marsh*; a great deal of good land near the sea was thus to be gained, and the new grounds along the upper part of its course were to be ameliorated. This undertaking was then Mr. Anstice's principal object; he was, as I have said, at *Uphill*, a village two miles distant from *Bleydon*; we went to his house, where he received me in a very obliging manner; and when I had explained to him my views, he entered into them immediately, that spot itself affording many objects worthy of observation.

899. The firſt of these which attracted my attention was an insulated hill, forming a promontory in the sea, in a line with the *Mendip hills*; its form and situation rendered me desirous to ascend it, and Mr. Anstice led me thither; it is covered with turf, and the parish church stands on its summit. This is a spot very favourable for observation, as well on the land side, as towards the coast; especially with a guide well acquainted with local circumstances. Looking towards the land, I saw the rocks of that extremity of the *Mendips* descending towards the sea in a most chaotic state, traversed by deep intersections, the lowest of which leaves insulated the hill of *Breandown*, whereon we were standing. It is here impossible not to perceive that this chain of hills is a long mass of *strata*, which, though remaining at a higher level than the rest, yet suffered also a *subsidence*, with angular motions of the separated parts, in the catastrophe whereby were produced, not only

the present bed of the sea, but two ancient bays which are separated by the extremity of these hills; for no cause in existence since the birth of the continents can have occasioned such a disorder; as will more and more appear by details concerning the coast and the chain of the *Mendip hills* themselves.

900. *Brean down* was originally an *island;* but having been surrounded with marshes on the sediments of the tides, the *Axe* continued its course through these, between the above hill and the foot of the *Mendips:* the new channel of the river was however to pass on the south of *Brean down,* and to be terminated by sluices like those already described at the extremity of the *Brue.* By means of this, the great extent of marsh, already connecting this original *island* with the land was to be entirely gained, and all these *marshes* secured against inundations, as well from the land as from the sea. Mr. Anstice made me remark a small island, lower than this, but near it, called *How rock,* and another of considerable size, at some distance in the sea, but still on the same line, called *Steep Holm;* and he told me that both these were composed of the same *strata* of *lime-stone* as the *Mendip hills;* which multiplies the monuments attesting the formation of the bed of the sea by a *subsidence* of the *strata;* the following monuments of a similar nature appearing also on the same coast.

901. Two other ridges of hills advance towards the sea to the north; and originally these had likewise

at their extremity large islands, which, having been united to the land by the extension of the *marshes*, are thus become *capes*, with circumstances so similar to the preceding, that it is easy to recognize in them the same catastrophe. The *cape* immediately following to the north, which was at first a large *island*, called *Worlebberry* from the name of a village there situated, has a small *island* very near it, called *Bearn Buck*, resembling the *How rock* before *Brean down*; and in the sea, in a line with this, and at the same distance as the *Steep Holm*, there is likewise a larger *island*, called the *Flat Holm*, on which is a lighthouse. To the north beyond this, another original *island*, called *Woodspring*, having been united to the land by the *marsh*, forms also a *cape*, bearing the name of St. *Thomas's head*; and before it, at a considerable distance in the sea, is a small *island*, called *The Wolves*. There are also two *islands* near the opposite coast of *Wales*. It cannot be by the actions of the *sea* that these *islands* have been separated from the land in *St. George's Channel*, which, on the contrary, is tending to be filled up with the sand brought into it from the open sea by the tides and the waves, and with the sediments of the land-waters: in consequence of this, large *sand-banks* have been formed here, which gradually approach the coast; of these the principal are *Culvensand* and *Gore*, in front of *Bridgewater bay*. Now in the history of the filling up of this *bay*, and the succeeding one on the north, there are *dates*, connected with the period when this coast was inhabited by the *Romans*; a circumstance which, in my *Lettres sur l'histoire de la Terre and de l'Homme*, I have also shown in the progress of the alluvial lands of the *Rhine*. At the bottom of the hill on the northern side of the bay, terminated by *Cape Bearn Buck*, Mr. Anstice pointed out to me a village still bearing the name of *Weston super mare*: this place therefore, as is recorded in the chronicles of the country, was situated on the sea-shore, in the time of the *Romans*, though at present it stands at a distance from the coast, in consequence of the increase of the *marsh*. There are other very remarkable monuments of the abode of the *Romans* near the *Brue*, and of the difference in the state of things at that time comparatively with the present; of these monuments Mr. Anstice told me some particulars, but I did not see them till my return hither the following year.

90[illegible]. There is here another phenomenon, very interesting in various respects; and Mr. Anstice was so good as to explain to me all the particulars of it, with which he was well acquainted: this relates to *peat*; and is applicable chiefly to the idea formed by Mr. Playfair respecting a similar phenomenon in the *Fens* of *Lincolnshire*, whereof, in p. 453, he gives an explanation which he presents as "a part of that "geological system of alternate *depression* and *elevation* of the surface, which probably extends to "the *whole mineral Kingdom*." He has formed this opinion, because he has not had opportunities of

studying

studying a great variety of coasts, especially those encompassing the *North sea*; on which, at the beginning of this volume, I have, with reference to the same object, pointed out similar phenomena, with their evident causes; I have adduced another example in *Torbay*, though indeed an inconsiderable one;. but this in the ancient bay of *Bridgewater*, or rather in the *marshes* which now occupy it, is very remarkable. I have said in general, that, wherever large *peat-moors* have been formed on a low original coast, the *peat* has slidden, or, more properly, flowed like a lava, below the waters of the sea, without being dissolved there; and that, when covered by the argillaceous and sandy sediments which form the soil of the *marshes*, it continues to flow under them, and even carries them down with it below the sea. Now this is exactly what Mr. Anstice has met with, in digging the new channels for the two rivers, and especially that for the *Axe*; where, at a great depth under the soil of the *marsh*, has been found a continuous bed of *peat*, more compact than that of the surface, as it has flowed, and is still flowing, from the bottom of the moor, and has passed under the pressure of the whole mass of the superincumbent *marsh*. But there is one circumstance which is very remarkable, because it indicates that there have been changes in vegetables, even on our present continents; the *atmosphere*, as I have explained in my *Elementary Treatise*, having experienced a sensible alteration, as well as the *liquid* of the *sea*, from the revolution whereby the bed of the latter was changed.

I have

I have given such examples of these successive changes in *animals*, as well terrestrial as marine, as can be referred only to the subsequent consequences of this revolution; and I now proceed to those in *vegetables*. Mr. Anstice told me that in this *peat*, which, having first slidden under the water of the sea, was afterwards covered by the *marsh*, had been found a prodigious quantity of the seeds of a plant no longer existing in the country, and hitherto generally unknown; these seeds are flat, and pretty large; their outside is still solid, but the interior part is quite decayed.

903. The two *bays* which follow to the north, between the above-mentioned *capes*, are also filled up; but the soil formed in them is different from that in the *bay* of *Bridgewater*, and these grounds are here called *fens*, to distinguish them from the *marshes*: they are not embanked like the latter, because, when they are covered by a high stormy sea, the waves do not injure their surface, on account of their being principally composed of sea-sand; no river discharging itself into either of these *bays*, and the few brooks which enter them bringing down but a small quantity of earthy particles comparatively with the three rivers arriving in that of *Bridgewater*, these particles being here only sufficient to bind the the sand. Thus the inundations of the sea have no other effect than to raise these lands by fresh deposites, and to widen the zone over which even the spring-tides, with a wind from the sea, no longer extend;

tend; and in time the whole space will arrive at this state. No hay is made on the parts still subject to inundation; but they afford good pasturage, and much cattle is reared and fattened on them. These meadows are intersected by ditches, into which the tides flow.

904. Here, therefore, we again find that the *land* has greatly gained upon the *sea*, on the *western* as well as on the *eastern* coast of *England;* and that this is effected by the very agents considered, in the Huttonian theory and many others, as at work in destroying the former; that is to say the waters, both of the land and of the sea, the sediments of which have, on the contrary, filled up these *bays*, as well as that of *Bristol*, farther to the north, on the same coast. As we viewed, from the hill whereon we stood, this great extent of *new lands*, in *marshes*, *fens*, and *moors*, I asked Mr. Anstice whether there was any map of *Somersetshire* in which these spaces were indicated by a different colour; he did not know that there was; but he said that, since it was my intention to return into this county the following year, he would, in the mean time, colour for me, in one of C. SMITH's maps, all the parts which, according to his own knowledge, and such information as he should procure, had been certainly occupied originally by the sea. I have this map at present before me; and I do not think that I exaggerate in estimating these *new lands* at the sixth part of the whole county.

905. The weather was at present fine, but large brilliant clouds announced that it would not long continue so. I intended, nevertheless, to ascend the *Mendip hills* by the *Chedder cliffs*, and to proceed over them to *Wells*; an excursion for which there remained but little time, as it was already so late in the autumn. I had wished to reach *Chedder* that night, meaning to go on from thence the next day on foot, in order to observe the state of the *strata* in these hills; but the distance from *Uphill* to *Chedder* was ten miles; it was already three o'clock, and there was no chaise to be hired in the neighbourhood: on this occasion, Mr. Anstice was again so kind as to assist me, offering to take me that evening, in his own chaise, to *Cross*, whence I should have but two miles to walk the next morning to *Chedder*; and while he went to order it, M. Pains, who was to return to *Bridgewater*, took me with him to the place where the masons were employed on the stone-work for the new channel and bridge of the *Axe*; and Mr. Anstice, who was to call there for me, recommended me in the mean time to Mr. Perrey, the architect who was carrying on this work.

906. On our arrival at this spot, M. Pains, before he quitted me, was so good as to think of doing me a good office for the following day, when I should no longer have Mr. Anstice to direct me; and he gave me a letter of recommendation to Mr. P. Fry near *Axbridge*, a small town between *Cross* and *Chedder*.

Chedder. Mr. Perrey, who professionally was acquainted with all the stony strata of the country, informed me that the *Mendip hills* were composed of strata of many different species of *marble*, of which some were very thick, but much broken, and the greater part considerably inclined. Among the materials collected for the work then carrying on, he shewed me the difference between this stone, and the *lyas* of *Polden hill*, on the other side of the *Brue*: the former was here only in irregular masses, which, being very hard, served for the foundations; while the *lyas*, by the regularity of its *strata*, furnished stones already of a proper thickness, not exceeding six or seven inches, and requiring only to be squared to form smooth walls; the stones in each row being taken from the same *stratum*. Great quantities of stones of the latter kind were collected here, and on the surface of many of these I saw abundance of small shells, mostly bivalves. Mr. Perrey informed me that scarcely any large shells were found in the *lyas*, while, in the stone of the *Mendip hills*, there were different species of them in the different *strata*. We were near the foot of a projecting part of these hills: he led me thither, and shewed me a stratum which contained a quantity of large *striated anomiæ*, with their shells preserved; telling me that *cornua Ammonis* were found in some of the higher strata. These great differences, as will in the nature of the *strata* themselves, as in that of the *marine animals* enclosed in them, show that these strata, though produced in parts of the bottom of the ancient sea so little distant from each other, cannot have been contemporary in their formation; and that great catastrophes must have taken place in the *strata* which now compose the *Mendip hills*, previously to the production of those of *lyas*. The perfect regularity of the latter strata indicates that the bottom of the sea must have remained a long time tranquil for their formation; but new catastrophes having subsequently taken place, they are now found broken into *hills*, with *inclinations* towards every point of the horizon; as will be seen in the course of my travels. And a proof of the great agitation of the bottom of the ancient sea, after the earlier catastrophes, as well of the *strata* of the *Mendips*, as of those composing the lower hills, appears in a *stratum* of *breccia* which Mr. Perry shewed me, and which, as he told me, lies over the *calcareous stone*, and is found in various places along the foot of the *Mendip hills*, often broken and *inclined*. In a subsequent journey, I found the same stratum in one of the great intersections of these hills. This *breccia*, of which the ground is reddish and very hard, makes no effervescence with aqua fortis, though it has sparry veins; the fragments contained in it are of *grey wacke*, some angular, and some rounded. This is a proof that these *calcareous strata* lie on those of *grey wacke*, contemporary with the *schisti*; and also that the catastrophes of the upper strata extended to those beneath them, as appears in the *Quantock hills* on the other side of the bay, of which I shall speak in a subsequent journey.

907. On the arrival of Mr. Anstice, in his chaise, I set out with him for *Cross*. We proceeded some way along the foot of the *Mendip hills*, where all the *moors* and *marshes* terminate: in this ridge there are many intersections; and we passed before one so deep, that, as I was informed by Mr. Anstice, a project was once entertained of cutting a canal through it, in order to establish an interior navigation between *Bridgewater* and *Bristol*, as a considerable supply of ship timber might be drawn from this part of *Somersetshire*. Beyond this intersection, rises a high insulated hill, named *Crook Peak*, appearing like a cone from the side whence we viewed it. The *strata* of this hill, which belongs to a part of the ridge of the *Mendips*, are nearly *vertical*, and show their sections in many projecting masses on its sides and summit: if it were not covered with grass, it would resemble the *Aiguilles* of the *Alps*. In the intersection on the other side of this hill is situated *Cross*, where we arrived just as night was coming on. Mr. Anstice intended to have returned to *Uphill* that evening; but when I saw the roads in which he would thus have had to travel in the dark, I persuaded him to stay and sleep at *Cross*; and his compliance, besides that it spared me much anxiety lest his kindness to me should have exposed him to any accident, gave me an opportunity of obtaining from him, in the course of the evening, much useful information relative to what I had already seen in this country, as well as with respect to the objects which still remained for me to observe.

Oct. 18*th.* Mr. Anstice having set out at seven in the morning on his return to *Uphill*, I sent M. Pains's letter to Mr. Fry, with an inquiry whether he could see me so early; and receiving from him in return an immediate invitation, I quitted *Cross* at eight o'clock, with a man to carry my portmanteau, and walked about a mile to *Compton house*, where Mr. Fry resided: he gave me a most obliging reception; and when he understood my intentions, he first sent to find a person who could serve me as a guide, and carry my little baggage, and then explained to me all that I should have to observe on my road: he was even so kind as to sketch for me a map of the course which I must take on the *Mendip hills*, after ascending them by the *Chedder cliffs*, in order to proceed to *Wells* by *Wookey hole*; but as the way was long and fatiguing, and the clouds threatened rain, he also sketched another road, leading down from the hills to *Westbury*, where I might spend the night in case of wet weather, and thence proceed the next day to *Wookey hole* and *Wells*.

908. The guide being arrived, and Mr. Fry having given him the necessary instructions, I set out with him from the village of *Chedder*, at the distance of two miles. *Axbridge*, so called from a bridge over the *Axe*, is near *Compton house*; but our road lay on the right bank of the river, and passed over the foot of the *Mendip hills*. Having reached *Chedder*, we began to ascend the passage called the *Chedder cliffs*, it being a deep cleft, two miles and a half in

length, reaching from the bottom to the top of the hills. This is a striking phenomenon in these countries, where, as the *stony strata* form only *hills*, the great *fractures* whence result long *defiles* are extremely rare; and I was glad to have it in my power to give an example here of a circumstance very frequent in *mountains*, particularly in the chain of the *Jura*, consisting also of *calcareous strata*, on which the catastrophes produced by the unequal *subsidences* of the *strata* have impressed the strongest characters. The *Chedder cliffs* belong to the class of *combes*; which differ from *vales*, because they do not divide ridges, but terminate near their summit, and in which, consequently, no *river* either passes, or ever can have passed. *Combes* are of various kinds: some are broad throughout the whole of their length, having resulted from two fractures, with a subsidence in the interval: some are narrow all the way, like that which I described in § 829, in the schisti of the *Bolt-head*; and these are simple fractures, widened by the inclination of one or both of their sides: lastly, others are complex fractures, with a subsidence of masses in some parts of their extent; and the latter is the case of the *Chedder cliffs*, as will appear by my description of them.

909. The catastrophes of the *strata* have here another of the characters which are observed in those of the *Jura* and of many calcareous mountains and hills; I mean interior *caverns*, resulting from the greater *subsidence* of some of the lower masses of the strata;

divided by fractures, and not followed by the masses above, the latter being supported on the sides, and forming the *roofs* of the *caverns*. It is, in such sucessive *caverns*, extending far inwards, and communicating with each other, that many small *rivers* are formed, which issue forth in vallies: streams of this kind appear in the vallies of the *Jura*; and there is an example of them at the bottom of the *Chedder cliffs*. A little above the village, but before I entered the defile, I saw issuing from the foot of the rocks one of the principal branches of the *Axe*, which immediately turns several mills. In these *caverns* there must be very deep reservoirs, wherein are deposited the earthy particles brought down from the surface by the rills of water which filtrate through the fissures of the strata; for the stream here issuing forth was perfectly limpid, flowing on a stony bed covered with moss; and this, as I learnt, is always the case, except after long rains. In some parts of the *Jura*, there are internal reservoirs of this kind which are so deep, that the water never issues otherwise than limpid, as from lakes.

910. Mr. Fry had charged my guide to shew me the mouths of three distinct series of *caverns*, which are in the sides of the *Chedder cliffs*: I saw the first of these on my right, at a certain height on the side of the defile, a little way beyond its entrance; the second, farther on, was at a higher level; and the third, on the left, was still higher, near the top of the defile. Mr. Fry, who had entered these *caverns*,

gave me the following general account of them. Each series is much interrupted, the caverns which thus communicate with each other not being all at the same level; some way beyond the entrance are found wide spaces, like halls, with the roof more or less elevated. To a certain extent these large cavities have narrow passages between them, on the same level; but afterwards, a face of a rock presents itself, above or below which there is an opening requiring a ladder to proceed; in some places, the new openings are lateral; and beyond each of them, the same signs of catastrophes recommence; larger or smaller vacant spaces, which communicate by narrow passages, being succeeded by a fronting rock, with a new opening, either higher, or lower, or lateral. Nobody has ventured to proceed so far as might be practicable in these successions of caverns, from the fear lest the candles should be extinguished by any mephitic vapours, or by the water which drops from the roof, and forms there stalactites; but it is evident that these subterranean passages extend a great way; and there is a tradition that a dog, having lost itself in the labyrinth of caverns beginning at *Wookey hole*, came out, several days afterwards, from one of those in the *Chedder cliffs*, in a state of extreme weakness and emaciation. No stream runs through the caverns opening in the *Chedder cliffs*; the water which enters them through the crevices of their roofs finds other crevices beneath, and descends through these into the lower reservoirs, whence the streams issue.

911. This general description of the *caverns* of the *Mendip hills* is perfectly correspondent with the nature of those which I have visited in several mountains consisting also of *calcareous strata*, wherein they so frequently occur; in particular, I have seen the *caverns* of the country of *Bayreuth*, celebrated on account of the animal *bones* found in them, buried under the stalactites with which their floor is covered to a great thickness: I shall describe these *caverns* in other travels which I hope to prepare for publication after the completion of the present work; but I must here mention a circumstance relating to them, as an example of the errors into which those are liable to fall, who form hypotheses respecting objects wherewith they have no acquaintance but from imperfect descriptions. This is the case with Mr. Playfair, when he says, p. 460, "The *caves* of *Bayreuth* seem "to have been the den and the tomb of a whole dy-"nasty of unknown monsters, that issued from this "central spot to devour the feebler inhabitants of "the woods, during a long succession of ages, before "man had subdued the earth, and freed it from all "domination but his own." Mr. Playfair, when he wrote this, had not had an opportunity of learning that the bones imbedded in the stalactites of these *caverns* are those of the *white bear*, an amphibious quadruped now living only in the northern latitudes, and, like the *seal*, never quitting the coasts: had he been informed of this fact, well known to those who have observed these bones, among which I have seen many entire heads, he would have understood that

caverns, now situated at a considerable height in the centre of our continents, could have been entered by these animals only while the sea was at the same high level; and that consequently these hills must have been *islands* of the ancient sea, produced, like all the mountains of our continents, by catastrophes of the *strata* anterior to the retreat of the ocean into its present bed. Amphibious animals entered these *caverns*, then near the shore of the ancient sea, as they now enter those on the shore of our modern sea; for example, I have heard that, at the foot of the rocks on some of the northern coasts of *Scotland*, there are caverns frequented in this manner by *seals*, which enter those retreats to bring forth their young, to devour their prey, or when they are dying; in the latter case, the caverns become their tombs: but the wild beasts of the land have no such places of common resort while living, nor catacombs whither they retire to die among the carcases of their companions; the whole surface of the earth being their habitation. And this only possible mode of accounting for these bones is confirmed by the following circumstance. The *caverns* of *Bayreuth* are at various heights, like those in the *Chedder cliffs*; and I entered several, both of the higher and of the lower: now it is only in those above a certain level, assuredly that of the ancient sea, that any bones are found; there are none in those below this line, which were under the water of that sea: and as I was informed by a guide who accompanied me, sea-sand is found under the accumulation of the stalactites in the latter caverns, as well as in those above them.

912. I return to the *Chedder cliffs*, the cause of which is so evidently seen to have been a great *fracture* across the *strata*, that nobody doubts of this on viewing the chasm; and the first idea naturally presenting itself to the mind, is to ascribe it to a violent *earthquake*. It is certainly, indeed, the effect of a *convulsion*, but of one very different in its nature; namely, of that which, in *strata* originally *horizontal* and *continuous*, produced *hills* above *plains*, and *vales* between the *hills*, and in consequence of which we now find the separated masses of these *strata*, forming the various *eminences* of our continents, to have acquired different degrees of *inclination*, even so far as to have become, in some places, nearly *vertical*; which revolutions will more and more manifestly appear in the description of the *Mendip hills*. In the *Chedder cliffs*, particularly, these dislocations of the *strata* are immediately evident, when the sides are compared with each other. In ascending this defile, the *strata* on the left side are seen to be much inclined towards the interval, while those on the right side rise towards it, but with a stronger inclination inwards; it having been this difference in their subsidence which occasioned their rupture.

913. The *strata* being here *calcareous* direct proofs appear, not only that they were successively formed, in a *horizontal* and *continuous* position, on

the bottom of the sea, but that the latter, during a long period, did not suffer any convulsion. The *parallelism* of the *strata* with each other, and the *marine bodies* contained in them, demonstrate the first of these circumstances; and with respect to the length of the period, it is proved by the successive change in the nature of the *strata*, though all *calcareous*, and by a correspondent change in the species of the *marine bodies*. These differences in the species of *marine bodies*, and in the nature of the *calcareous strata* containing them, I had found in the *Jura*, and in several other mountains which I had formerly observed; that I should find them also in the *strata* of the *Chedder cliffs*, I had already learnt from Mr. Pertey; and I accordingly perceived them in the masses fallen from different heights, which contained shells of different species; but I shall speak only of one particular stratum, consisting of a black marble. Of this I saw blocks placed as seats before the houses in the village of *Chedder*, and I remarked in them a quantity of round white spots, the nature of which I was not able to distinguish, because the surface of these blocks had been coarsely wrought. I found abundance of fragments of this stratum at the foot of the rocks of the *Chedder cliffs*, all marked with these indistinct white spots; nor could I form any determinate idea respecting them, till I came to some blocks of the same kind, nearly two feet in thickness, and lying on their flat side, which had remained so long exposed to the actions of the air, that, on their surface, the stone itself had been decomposed, and the marine bodies contained in it were left in relief: they were *ramified corallines*; and had a slab been sawn off from the upper surface of one of these blocks, it would have formed a beautiful specimen for a cabinet. I then perceived that the white spots which I had observed in so many other blocks were in transversal fractures of the stratum, the whole being filled with the same *corallines*.

914. Many other circumstances concur in manifesting the nature of the catastrophe which produced the *Chedder cliffs*, and among these is, first, its unequal breadth. Though some parts of this defile bear the character of a simple *fracture*, by the small distance between the sides, and by the salient and retreating angles opposite to each other, which are found in most of the defiles produced by such fractures, there are in it some very wide spaces; and on attentively examining these spaces, especially with respect to the different situations of the strata on their opposite sides, it cannot be doubted that large masses of all the strata have there *sunk* together from the top; while the *caverns* have been produced in the masses remaining higher by a greater *subsidence* of their lower parts.

915. Another circumstance which shews the nature of this catastrophe is the great inequality of the slope of the bottom of the *Chedder cliffs*, now

serving as a high road to cross the *Mendip hills*. In some parts of this road, there is a very rapid ascent; after this, there are spaces nearly horizontal; and the situation of the *strata* on both sides, along the whole extent, shews that these differences have been produced by *subsidences*, successively, but irregularly, more and more considerable, after longitudinal fractures of the entire mass of the strata, from the top of the hill, down to the present bed of the *Axe*; independently of the transversal fracture whence have resulted the *Chedder cliffs*. I could not obtain any account of the manner in which a road was made here, nor, consequently, respecting the original state of the bottom of the fracture, now rendered even and smooth. But of many similar roads in the chain of the *Jura*, the history is well known; and there is even, in particular, a fine monument erected in honour of one of the Dukes of *Savoy*, who made a great road from *Savoy* into *Dauphiny*, through a defile which much resembles the *Chedder cliffs*, and still bears the name of *Passage des Echelles*, (Passage of ladders,) because formerly there was no path here but for foot-passengers, who, when they reached the end of the defile, were obliged to go down *ladders* to the bottom of an abrupt section of the mountain. There is a Latin inscription on this monument, describing, in the lapidary style, the former state of the passage, and what it had been necessary to do, in order to make a road for carriages. The bottom had been full of pointed rocks, and in some parts of it there were very deep cavities. In order to fill up these, vast quantities of the masses on the sides were blown up with gunpowder, and thrown down into the largest intervals of the rocks below; and the surface was afterwards levelled with the smaller fragments: then, after cutting away a great part of the abrupt section without, and throwing there abundance of rubbish, a winding road was formed. The whole of the labour employed in this work has, however, produced only what a great many torrents have effected in mountains, when, having been carried along by a rapid declivity, they have levelled the bottom of defiles with the materials which they have brought down in clearing the upper parts of their beds. But no stream can ever have passed down either the *Chedder cliffs*, or the *Passage des Echelles*; so that art has been here obliged to intervene.

916. It is thus that, though the *Mendips* can be ranked only among hills, the *Chedder cliffs* furnish instances of several of the phenomena which belong to mountains composed of stony strata: and these cliffs will, at the same time, afford me an example of a kind of *chronometer*, likewise uncommon among the hills of these countries, where most of the external features of the catastrophes of the *strata*, as well on the summits as on the slopes, are concealed by a thick loose soil of a different nature. The whole of the description which I have hitherto given of the *Chedder cliffs* evidently proves this fracture of the strata to have existed at the birth of the continents; it having been merely an accidental effect of the

cause (the nature of which I do not here consider) that produced great angular motions in the divided masses, now forming the chain of the *Mendip hills.* It is therefore only since the birth of the continents that gravity, and the various atmospherical actions, (including the frosts which detach masses from the rocks,) having acted on the abrupt sides of the *Chedder cliffs*, and having caused them to crumble down, the fallen materials have accumulated under them, and rising against them in *taluses*, have prevented the farther demolition of the parts which they thus have covered. These *accumulations*, by their own *progress*, and that of *vegetation* on their slopes, constitute one of the classes of *chronometers* common to all mountains, respecting which I have entered into many details in my *Lettres sur l'Histoire de la Terre & de l'Homme*; it is to be found in many parts of the sides of the *Chedder cliffs*; but I shall here speak only of the most remarkable *talus*, situated on the right side of the defile, not far beyond its entrance from *Chedder*. There was here originally an abrupt façade, very high and broad, but composed of strata so much shattered, that gravity, and frosts when the crevices are filled with water, have caused it to crumble down very rapidly. Hence results a *talus* of the rubbish, which has spread so much as to have rendered this part of the defile very narrow, and also has risen to a great height against the originally abrupt side, near the top of which is the mouth of the first of the caverns above mentioned. This fall of materials certainly *began* as soon as the continents had been

abandoned

abandoned by the sea; it has been ever since *continuing*; in some parts, the operation is at an *end*, but in others, it is still going on. This is shewn by the *vegetation*, which cannot permanently establish itself on a talus, while much rubbish continues to fall. Now the part of this *talus* nearest to *Chedder* is, to a great extent, covered with turf nearly up to the foot of the rocks; and I saw a flock of sheep grazing on it. The mouth of the *cavern* being above this part, the access to it is difficult and fatiguing, especially in dry seasons, when these grassy slopes are extremely slippery. Beyond this, the falls of rubbish are still too frequent to allow the grass to spread very high; and in some parts, there is none yet but towards the bottom. This is, as I have said, the most remarkable example in the *Chedder cliffs*, on account of its extent; but in many other parts of their sides, it is repeated on a smaller scale. If the continents had existed during a very great number of ages, all these *taluses* would now be covered with grass up to the top. This is an universal *chronometer*, in all the mountains of the continents, and at every *height* in those mountains, wherever any of their sides have been abrupt; it attests the small *antiquity* of the *continents*; and I was particularly glad to meet with an example of it in the west of *England*, on account of the correspondent phenomena which I have already described, and shall continue to describe, on the coasts.

917. The *fracture* which produced the *Chedder cliffs* having passed through a great thickness of the

strata, the great variety of their composition, though they are all *calcareous*, is shown by their fallen masses; and this variety can only be attributed to *precipitations*, successively changing in the same *liquid*, on account of the new ingredients arising from the interior part of the globe, through fractures of the *strata*, which had undergone previous catastrophes; and these changes, as I have said above, are likewise indicated by those in the species of the marine animals found in the strata. Moreover, the fracture having been very winding, great differences appear in the situations of the *strata* on the opposite sides. I have also said, that, in ascending the defile from *Chedder*, the *strata* on the left are seen for some way to incline towards the chasm, while, on the right, they have a much stronger inclination, and dip inwards; but when the defile makes any considerable turn, the appearance of its sides changes also very considerably; the *strata* do not there follow its slope by their simple inclination; they descend towards the course of the *Axe* in several terraces, each preceded by a fracture; and it is the difference of inclination in these terraces, which has produced that above described in the slope of the defile.

918. After having ascended this road, which is about two miles and a half in length, I came into a winding vale crossing the upper part of the hill. It may be judged that the sides of this vale, especially that on the west, were originally more steep than they are at present; they have crumbled down

and their *taluses* are covered with turf, through which appear in many places the summits of the *strata* inclining inwards. At the end of a certain space, this vale is divided into two branches; one of these continues its course across the hill, and goes to *Rowborough*, on the north; the other follows the direction of the hill, turning to the east, towards *Priddy*. These are *vales* that certainly have not been excavated by *running waters*, for there are no streams on the summits of hills: they have manifestly resulted from the catastrophes of the *strata*, which, as they dip inwards, shew every where their edges on the summit; and of which the different degrees of *subsidence* have produced their inflexions of the surface. And besides, it clearly appears that here no waters can have acted but those of the sea; for, instead of a loose soil composed of small fragments of the *calcareous strata*, this summit, as I shall shew, is covered with a deep *sand*, which cannot have been brought hither from any quarter, since the continent has existed.

919. Continuing my road, I ascended the vale leading to *Priddy*; but my walk now became extremely disagreeable, because the rain, which had already begun when I reached the top of the *Chedder cliffs*, much increased, and continued very violent during the rest of the day. My way up the vale was for some time bordered by walls newly constructed with fragments of the calcareous strata, for the enclosure of lands which it was intended to improve,

improve. So long as I walked between these walls, the grass, being trodden down by passengers, wetted only my feet; but beyond this part, the road branched off in various directions, and as I was to guide myself by the objects marked in Mr. Fry's little map, without following any beaten track, I was obliged to walk through high fern, which wetted me up to the knees, as much as if I had been in the water; and I then had reason to be very thankful for his kind foresight in also sketching the road to *Westbury*, which I determined to take, as there was no probability that the rain would cease.

920. *Stoke Lodge*, a house inhabited by the keeper of a warren, now became the object to which I was to direct my course; I had therefore nothing to do but to walk in a strait line towards it, though I often lost sight of it by the deep inflexions of the summit, produced by greater *subsidences* of the *strata*, which strongly inclined inwards, and being irregularly broken off above, raised their heads here and there through a very thick covering of pure *sand*. I could avoid these points wherever they appeared above the fern; but many were hidden by it; and I was therefore obliged to walk with great caution, lest striking too strongly against some of them, I should fall on others. Nor was this the only obstacle which impeded me in my walk; for the moles working easily in the sand, all this part of the top of the hill was full of mole hills, partly concealed also by the fern.

921. After having crossed a wide and deep inflexion, in which the points of the dipping *strata* rose every where above the turf, I ascended the following hill, and found the *sand* inhabited there by a different race of animals: I was now on the warren, where the very numerous burrows of the rabbits were as troublesome to me in walking as the mole-hills had been; my feet often sinking into the holes concealed by the fern. The rain continuing with great violence, I hastened to reach the warrener's house, where my guide having introduced me as recommended by Mr. Fry, I was received with the utmost hospitality, of which I was really much in need. I found there a whole family, men, women, and children, all employed in making or mending the purse-nets used for catching rabbits: they lighted a great fire to dry my guide and myself, while they set before us what their house could furnish, bread and cheese, and beer; and on these we made such a comfortable meal, as enabled us to continue our walk, after having rested ourselves for an hour, during which I made some inquiries of these people respecting the management of the warren.

922. In crossing it, I had remarked some lime which seemed, within a certain extent, to have been thrown on the ground by handfuls; and asking my hosts whether this had been done intentionally, and for what purpose, they informed me that it was to mark the places where they had already taken rabbits this year, that they might not return to them till

the next; by which time this lime would be washed by the rains into the ground, where it served also to promote the growth of good herbage. They told me that, proceeding in this manner, they took about 3000 brace of rabbits every year; a number to which they were limited by their lease, under the penalty of damages payable to the proprietor, as the warren was always to remain stocked to a certain degree. I asked them how this matter could be determined between them and the proprietor; they told me that the warrens were visited every year, at a particular season, by sworn inspectors, who could judge very exactly whether they were stocked as fully as they ought to be, and who made their report to the owners; on this report, if the warreners were found to have destroyed too many rabbits, the magistrates had power to oblige them to the payment of a sum adequate to the damage, and even to annul their lease. In catching the rabbits, this warrener has some competitors; these are the badgers and polecats which have their holes in a wood on the slope below the warren; but he has much the advantage of them in cunning: he has built a low wall along the warren on that side, with several openings, which, while they leave an issue for the rain waters, likewise offer an entrance to the inhabitants of the wood; but only to lead them into traps set there to catch them.

923. In fine weather, I could very well have descended from this spot to *Westbury* with only my

guide, though he had never gone down this side of the hill, for we should easily have found paths on the slopes; but it is very disagreeable to seek them in the rain, and when the grass is wet; I therefore begged one of the warrener's men to accompany us, till we should have proceeded far enough to be out of danger of losing our way. In this descent, I very much regretted that the weather was so bad; for had it been fine, I should have enjoyed extremely the beauty of the prospect, which included the whole of the ancient bay of *Bridgewater* now changed into meadows covered with herds, together with the surrounding hills. However, the rain did not prevent my observing, on this border of the *Mendips*, phenomena entirely similar to those around the lakes of *Switzerland* and *Savoy*, which I descibed in my *Elementary Treatise* as visibly showing how those *cavities* had been produced, namely, by the *subsidence* of the *strata* originally occupying the spaces now vacant; for I saw on this slope ridges of small hills, gradually descending to the border of the meadows, and composed of large masses which had fallen forward, presenting at the top the section of their *strata* strongly inclined towards the vacant space.

924. At four o'clock, we arrived at the village of *Westbury*, where, at the inn of the *Horse and Groom*, (which I have pleasure in mentioning,) I found very kind people, who, when they saw us so completely wet, were eager to do us every friendly office. They lent me dry clothes, and made a good fire for me, by

the side of which I spent the evening writing my notes, and drinking tea; and I then retired to a comfortable bed, where I recovered tolerable well from the fatigue of this hard day's work.

Oct. 17th. I set out from *Westbury* at eight in the morning with a new guide, and went on foot to *Wookey hole*, the *cavern* already mentioned. It was now fine weather; and as the cheerful aspect of the low hills in a valley crossing the chain of the *Mendips* recalled to my imagination the pleasure which similar excursions had given me in my youth, it supported me in another walk through the wet grass *; though indeed this walk contributed to the ill effect which the latter part of this journey subsequently had on my health.

925. I thus arrived at a hamlet which is called *Wookey hole*, from the name of the cavern, though at some distance from it. The entrance of the *cavern* is closed by a door, and the key is kept by a man belonging to the hamlet: my guide took me to his house, and he came with a lanthorn to accompany us. The most remote branch of the small river *Axe* proceeds from the cavern, but it issues through a crevice at the foot of the high hills which border the western side of the valley, and enters a narrow glen, whence coming out into the valley, it serves immediately to turn the wheels of a paper-mill: I ob-

---

* Mr. De Luc was at this time in his seventy-ninth year. T.

served that it was perfectly limpid, notwithstanding the rain of the preceding day, and it flowed rapidly on a stony bed covered with moss.

926. The hill presents, on this side, a great section of the lime-stone strata, in the base whereof is the cleft through which, as I have said, the *Axe* first flows: ascending the southern side of this cleft through a coppice, we reached a spot above that whence the river issues, and saw the stream rush out foaming from a fissure considerably below the entrance of the *cavern*. This entrance is artificial; the stream was heard as it still is, to fall in a cascade within the hill, which was pierced in order to discover the course of the waters; and thus accidentally was opened a way to *caverns* hitherto unknown; the passage to them laterally communicates with the crevice whence issues the stream. I did not proceed farther, not thinking it prudent, after my preceding excursions, to expose myself to the chill of the interior damps: however I saw the torrent, which is formed in *caverns* above those accessible from this point; and of what is observed beyond, I contented myself with the description given to me by the guide. After proceeding a certain way along a narrow passage, a spacious *cavern* is entered, with a very lofty roof; hence there are passages equally narrow, leading to two other *caverns*, which generally satisfy the curiosity of those who visit these subterranean recesses; as they contain large masses of stalactites, and in particular a group of very grotesque appearance, con-

sisting of a large pyramidal figure somewhat resembling a woman, with several smaller ones around it, commonly known by the name of the *Witch of Wookey and her imps.* Another passage, however, opens here, by which more adventurous visitors have proceeded much farther, finding new caverns and new passages, the end of which has never been reached. Here I was again told the tradition of the dog who had entered *Wookey hole,* and came out, several days after, from one of the caverns in the *Chedder cliffs.* In my next journey, I shall relate a similar event, which happened not long ago in some *caverns* near the river *Dart,* and which was told me by the master of the dog.

927. I shall stop here, to consider these *caverns* so frequent in mountains, especially the *calcareous,* on account of the solidity of their *strata,* which, at the same time, have no adherence to each other; whence it proceeds that the lower masses so easily separate from the upper, when the fractures, necessarily produced in the motions occasioned by an unequal subsidence, do not pass directly from one stratum to another; for then some superior masses may remain supported laterally, while those under them sink lower, because they have no support beneath. This evidently has been the origin, not only of interior *caverns,* but of those great *projections* resembling pent-houses, frequently seen to a considerable extent, in the steep sides of calcareous mountains; the lower strata having abandoned the upper,

in the catastrophe by which these abrupt sides were formed: from this cause resulted what are called *Les Voûtes* in the mountain of *Salève* near *Geneva, La Cluse* in the mountains of *Neufchatel*, and many other similar phenomena which I have elsewhere observed. Now this will lead us to a point of great importance in Geology.

927. *a.* It must be acknowledged by all those who thoroughly understand the present state of our *mineral strata*, their *ruptures*, and the *angular movements* which their separated masses must have undergone, (as I have above shewn in the *Mendip hills,*) that such alterations in *strata* originally *horizontal* and *continuous* can have proceeded only from one or the other of these two mechanical causes: "Either "the *elevation* of the parts which are now the "*highest*, or the *subsidence* of those which are now "the *lowest*." This dilemma is absolute; and equally so is another concerning the *continents* themselves. When we have studied these with attention in all their parts, from their centres to their borders, from their greatest elevations to their lowest depths, when we have seen the regularity of the *strata* composing the whole of their observable mass, and the quantity of the *marine bodies* contained in these *strata*, it is also impossible not to acknowledge that we are inhabiting an *ancient bed* of the *sea*: now, "Either this *ancient bed* of the *sea* has been *raised* "above the level of the water, and a *vacant space*, "proportional to the change of *level*, has been left

"beneath the mass thus *raised;* or the *sea*, retiring "from this *ancient bed*, has covered a portion of the "globe which *subsided* in a *vacant space* previously "existing under it, and has in this manner been re"duced to its present *level.*"

928. These *dilemmas* are both absolute, but distinct from each other; inasmuch as one relates to the state of the *mineral strata*, the other to the existence of the *continents;* and it is by confounding these two objects, that Mr. Playfair has formed what he considers as a peremptory argument in favour of the theory of *elevation*, contained in the following passage, p. *52*. "In establishing this *conclusion*, "we have reasoned more from the facts which relate "to the *angular elevation* of the *strata*, than from "those which relate to their *absolute elevation*, or "their translation to a greater distance from the "centre of the earth. This has been done, because "the appearances, which respect the absolute *lifting* "*up* of the strata are more ambiguous than those, "which respect the change of their *angular* position. "The former might be accounted for, could they be "separated from the latter, in *two* ways, viz. either "by the *retreat* of the *sea*, or the *raising up* of the "*land;* but the latter can be explained only in *one* "way, and *force* us *of necessity* to acknowledge the "existence of an *expanding power*, which has acted "on the *strata* with incredible energy, and has "been directed from the *centre* toward the *circum*"*ference.*"

929. Mr. Playfair was certainly convinced that his consequence was necessary; but he could not have thought so, as I have already shewn in my *Elementary Treatise*, §. 174, had he paid any attention to my Letters to Dr. Hutton; for he would there have seen beforehand that his reasoning was a mere *petitio principii.* According to the supposition entertained in the theory which he supports, that the birth of the continents is due to the *elevation* of the *land* above the *level* of the *sea*, the *fractures* and *angular motions*, of the *strata* must also be ascribed to that operation; and indeed, in this theory, they are even adduced as a proof of it. Hence, not having considered the demonstration given in my works, that these catastrophes of the *strata* had *previously* taken place on the bottom of the *ancient sea*, but imagining me to suppose that this state of the *strata* was produced *at the birth* of the *continents*, he has maintained, with reason, that such a state could not possibly have resulted from the simple *sinking* of the *level* of the *sea*, which I assign as the cause of that *birth*, the continents having been only left dry, without any material change in their construction. But besides this essential omission in his reasoning, there were still remaining to be set aside some other considerations, which I had developed, and shall now recall.

930. Our *strata* have undergone many *successive* catastrophes; and this is demonstrated, first, by the *breccias*, or strata containing fragments of those which had preceded them, found between others of

various kinds produced in the same places; and more visibly by the *strata* of *lime-stone* and *sand-stone*, formed on those of *schistus*, many of which had already been subjected to *angular motions* in earlier catastrophes. Dr. Hutton had seen the latter phenomenon in *Scotland*, and he had found other instances of it in the descriptions of various observers; among the rest, in my *Lettres sur l'Histoire de la Terre & de l'Homme;* and it not being possible to explain these phenomena by a single *elevation*, he contrived the subsidiary hypothesis, that, after the *elevation* of the *continents* themselves, some of their parts had *subsided*, and returned below the waters of the sea, where new *strata* had been formed on them, with which they had again been *elevated*. These alternations must be supposed to have been often repeated in the same places; not only because of the repetition of the *breccias* in the successions of various genera and species of *strata* in the same mountains, but on account of the new catastrophes undergone by all these classes of strata laid one upon another. Such is indeed the supposition of Mr. Playfair, when he repeats this hypothesis, first in the text, §. 43, and then again in his note on that paragraph, at the bottom of p. 211.

931. We have here an example of the great difference found in conclusions drawn from phenomena, accordingly as those phenomena are known from actual observation, or merely from descriptions, which are rarely such as to comprise all the objects

connected with them. It was only in *Scotland* that Dr. Hutton and Mr. Playfair had observed any examples of the phenomena of which I am now speaking: of those on the continent they knew nothing but by the accounts of others; it is true that they have taken some of these accounts from M. de Saussure's *Voyages dans les Alpes;* a work wherein the descriptions are very exact, and where many of the objects are presented with all their connexions; but in this instance, as well as in many others pointed out in my *Elementary Treatise,* these gentlemen have selected the particular facts which have appeared to them to agree with their own hypotheses, without considering such of the relations between those objects and others as would have prevented their conclusions. In general, it is well known by those who have attentively observed the state of the *strata* in a great many different parts of the continent, that the phenomena of the breccias, and of the new strata produced on others which had undergone previous catastrophes, are everywhere found in the interior parts of the lands. Now to suppose partial *subsidences,* succeeded by new *elevations,* would be impossible, because these phenomena are observed in continuous chains of mountains, which exhibit throughout the same kind of contemporary catastrophes; and it would also be useless, because, though partial *subsidences* in interior parts of the continents might indeed have occasioned *lakes* in those spots, they could not have brought over them the *sea,* to produce there new *strata,* similar to those which compose other parts of the continent, and containing marine bodies. No resource therefore remains for the hypothesis, but to extend to the *whole continent* this supposition of alternate *elevations* and *subsidences;* and then, besides that such a supposition would strike the mind as absolutely improbable, it would render more evident the fundamental objection which I have made against the theory of *elevations.* For how could it be imagined, that such masses as the continents, so repeatedly *fractured,* with *angular motions* of their separated parts, could have remained *suspended* over *cavities* of the same extent as themselves, which must necessarily have been produced by their *elevation* from the bottom of the ocean to their present level, when it is considered that this *suspension* must have continued after the escape of the supposed *expansive power,* the *fiery vapour* as Dr. Hutton called it, through the millions of fissures produced in this immense vault! Lastly, in order to account for the formation of the *breccias,* by external causes, on the parts already *elevated,* according to the Huttonian theory, and for the formation, by the *sea,* of new *strata* very different from those which had *subsided,* either on those *breccias,* or on *strata* broken by a previous elevation, it would be necessary to suppose great intervals of time between early *subsidences* and new *elevations,* for the production of these great changes in the nature of the *strata.* Now in §. 743. I have described in *Antony hill,* near *Bath,* some *strata* of a peculiar species of *lime-stone,* the first of which having assumed a great inclination, others of the same kind were subsequently formed above them; a circumstance indicating that, for some time after the catastrophe of the former strata, there was no change in the state of the sea.

932. It therefore remains beyond all doubt, that the catastrophes of which visible marks are impressed on the whole mass of the *strata* composing our continents, so far as we can be acquainted with them, had already taken place on the bottom of the *sea*, before it was abandoned by the waters; and it is from inattention to this part of my system, or rather to the *facts* supporting it, that Mr. Playfair considers these catastrophes as incompatible with the *birth* of the *continents* by the simple *lowering* of the *level of the sea.* In my Elementary Treatise, I have explained the manner in which the above catastrophes were produced on the bottom of the *ancient sea*, together with many of the circumstances connected with them; and I have shewn that these great changes in the state of the strata were the effect, not of *elevations*, but of repeated *subsidences*. Now all the preceding considerations are supported by the existence of *caverns* in so many mountains; for I have explained above how such cavities were formed during the *subsidences* of the *strata;* while in the *elevation* of these strata by a force acting from *beneath*, no *interval* could have been produced between them.

933. From *Wookey hole* I walked on to *Wells*, at the distance of two miles; and thence, after having

rested myself, I set out for *Bath*. The city of *Wells* is situated in a deep intersection of the chain of the *Mendip hills*, which extend a considerable way farther to the east, becoming however gradually lower. On observing in this intersection some associations of other species of strata, I became desirous to follow the chain farther on the eastern side; and this I did four years afterwards in a journey of which I shall give an account. That the valley of *Wells* was produced by two fractures irregularly distant from each other, attended by a subsidence of the intermediate mass, appears very clearly from the aspect of the western side, where the eminences are highest; for this side is full of pointed rocks, shewing the upper section of dipping *strata*, the intervals between which are covered with turf.

934. After I had passed the *Mendip hills*, I found a great change in the appearance of the country. I came first to some scattered hills composed of *red strata*, like those on the opposite side of the chain; and beyond these, I entered the district of the *lime-stone strata*, which I have already described in the neighbourhood of *Bath*, and of which, therefore, I shall mention only one circumstance; this is, that, as I approached *Antony hill*, I saw by the road-side some quarries, shewing, on this western side, the continuation of the phenomenon formerly observed on that hill; namely, *strata* of *lime-stone* strongly inclined, on which others of the same nature have been

formed in a situation nearly horizontal; the whole being here at a lower level than *Antony hill.*

I here terminate my account of this journey. I rested myself for a few days with my friends at *Bath,* and then returned to *Windsor.* I was ill almost the whole of the succeeding winter, to which my walk over the *Mendip hills* had probably greatly contributed; so that for some time I despaired of being able to accomplish my projects of future observation; having however, I thank God, tolerably recovered my health, I carried all my plans into execution in the course of the two following years.

INDEX

TO THE

PLACES MENTIONED IN THE SECOND VOLUME.

A.

Abbotsbury, §§ 516, 520, 540.
Allen R. (Dorsets.) § 593.
Alum bay, §§ 600, 612—614.
Antony hill, §§ 740—746, 934.
Anstis cove, § 798.
Aven R. §§ 833, 839, 840, 882.
Avenmouth, §§ 833, 838, 840.
Aveton Giffard, § 839.
Avon R. §§ 713—715, 720, 726—732, 735.
Ax R. § 753.
Axbridge, § 908.
Axe R. §§ 888, 897, 898, 900, 902, 908, 909, 915, 917, 925, 926.
Axminster, § 753.

B.

Babicomb bay. §§ 792—798, 801.
Bath, §§ 691—699, 729—747, 934.

Batheaston,

Batheaston, §§ 731, 737
Bawdsey cliff and haven, §§ 457, 458.
Bentham, §§ 838, 839.
Berry head, §§ 805, 817.
Bicton, § 761.
Bigbury, §§ 833; 839—843.
Bigbury bay, §§ 822, 825, 828, 833—841, 847, 848.
Blackauton, § 824.
Blackdown hills, § 885.
Blandford, § 590.
Boltbury, § 832.
Bolt-head, §§ 822, 828—830.
Bolt-tail, §§ 822, 828, 832, 835.
Bonchurch, §§ 626, 627, 630.
Boniface down, §§ 624, 628—630.
Bovey R. § 784.
Bovey coal-pit, §§ 784—787, 1055.
Bovey heath, §§ 784, 882.
Bovey Tracey, §§ 784, 788, 790.
Bradbury ring, § 592.
Brading, § 636.
Brean down, §§ 899—901.
Bredy R. §§ 529, 536, 540, 541.
Brent, § 882.
Bridgewater, §§ 885—895.
Bridport, §§ 529—543, 558, 559, 753.
Bristol, §§ 713—715.
Brit R. §§ 529—531.
Brue R. §§ 888, 895—897.
Buckland tous-saints, § 825.
Bur I. §§ 838, 839, 841.
Burton Bradstock, §§ 535, 541.
Burton cliff, §§ 537—541.

C.

Catherine brook, § 737.
Catwater, §§ 856—860, 873 a, 874, 882.

Cawsand bay, §§ 875, 876.
Char R. §§ 543—546, 555.
Charmouth, §§ 543—546, 555, 557, 753.
Chedder, § 908.
Chedder cliffs, §§ 908—917.
Chesil, §§ 495, 503.
Chesil bank, §§ 479, 493—496, 502—516, 520—523, 536.
Christchurch, §§ 595—597, 601, 602.
Chudleigh rock, §§ 790, 883.
Churston Ferrers, § 804.
Claverton down, §§ 730—735.
Clifton, §§ 716, 726.
Clyst R. § 760.
Corfe R. § 679.
Corfe Castle, §§ 668, 678.
W. Cowes, §§ 639, 640.
Crimble passage, §§ 873, 873 *a*.
Crook peak, § 907.
Cross, § 907.

D.

Dart R. §§ 805—807, 818—820, 822—824, 882.
Dartmoor, §§ 783, 788, 789, 805, 819.
Dartmouth, §§ 806, 808—814, 822—824.
Devil's point, §§ 872, 873.
Dittisham, § 817.
Dorchester, §§ 528, 589, 753.

E.

Eddystone, § 880.
Erme R. §§ 843—850, 882.
Ermemouth, §§ 843, 847—849.
Ex R. §§ 753—755, 758, 759, 761, 772, 884.
Exeter, §§ 753—759, 884.
Exmouth, §§ 770—778, 884.

F.

Felixton cliffs, § 459.
Fleet, §§ 515, 526.
Forward, cape, § 805.
Freshwater gate and bay, §§ 611, 616.
Froome R. §§ 589, 675—677, 683.
Furzleigh hill, §§ 788, 789.

G.

Gampton, § 805.
Glastonbury, § 888.
Goat's head, § 831.

H.

Haldon hills, §§ 883, 884.
Hamble R. § 641.
Hamoaze, §§ 854—856, 857 *a*, 858, 863, 867—869, 873—875.
Harwich, §§ 459—463.
St. Helens, § 637.
Highbridge, § 896.
Hodicomb cove, §§ 796, 797.
Holm Islands, Steep and Flat, § 900.
Hope cove, §§ 832—835.
Hope's nose, §§ 798, 801.
How rock, § 900.
Hurst Castle, § 604.

I.

Itchin R. § 642.
Ivybridge, § 882.

K.

Kingsand, §§ 875, 876
Kingsbridge, §§ 810, 822, 825, 826.

Kingsdown, §§ 735—737.
Kingswear, §§ 806, 808.
Kingswood, §§ 701—706.

L.

Langport, § 892.
Langton Herring, §§ 517—519, 526.
Lansdown, §§ 693—696, 699.
Larderum cove, §§ 762, 763.
Lowestoffe, §§ 453—455.
Lulworth, §§ 649, 683.
Lyme, §§ 550—554.
Lymington, §§ 596, 601—605.

M.

Maker, § 875.
Marlborough downs, §§ 688, 689.
Marystow, §§ 861, 863, 869.
Melcomb Regis, §§ 476, 564, 567.
Mendip hills, §§ 887, 888, 895, 896, 899, 900, 906—933.
Mount Edgecombe, §§ 872—875.
Muddicombe, §§ 843, 847—851.

N.

Needles, §§ 600, 612, 614.
Newport, §§ 618—620, 639.
St. Nicholas's I. §§ 857, 857 *a*, 873.
Niton, §§ 621, 622.

O.

Orfordness, §§ 455, 456.
Oriston, § 852.
Osmington, §§ 584—588, 685.

Otter R. §§ 759, 761, 769.
Otterton, § 761.

P.

Paington, § 803.
Parrot R. §§ 888, 890, 892—894.
Peverel point, §§ 651, 753.
Pill, § 715.
Plym R. §§ 852, 853, 856, 857—860, 882.
Plymouth, §§ 852—857, 871, 872, 881.
Polden hill, §§ 887, 895, 896 906.
Poole, §§ 593, 673.
Poole harbour, §§ 670—676.
Portland I. §§ 479, 492—511.
Portlemouth, §§ 810, 822, 825, 828.
Praule point, § 830.
Purbeck I. §§ 651—683.

Q.

Quantock hills, §§ 887, 895, 906.

R.

Radipole, §§ 569, 571, 572.
Rame-head, §§ 875, 878, 879.
Reading, § 687.
Ride, § 637.
Roborough downs, § 869.

S.

Salcomb, §§ 822, 825, 827, 828, 833.
Sandwich bay, §§ 652, 656.
Sequer's bridge, §§ 843—846.
Shaldon, §§ 781, 792.
Shingles, § 604.
Shirehampton, § 720.

Sid R. §§ 759, 761, 765, 767.
Sidmouth, §§ 766—768.
Simene R. §§ 529, 531.
Slapton Lee, §§ 810, 811.
Southampton, §§ 641, 642.
Start bay, §§ 805, 808, 810, 824, 825.
Stert point, § 890.
Stoke lodge, §§ 920—922.
Stour R. §§ 590, 591, 595.
Straton point, §§ 575, 579, 588.
Studland bay, §§ 656, 669—676.
Swanage, §§ 653—667.

T.

Tamer R. §§ 852—856, 861, 862, 864—869, 873, 875.
Tavistock, § 868.
Tavy R. §§ 861—865, 867, 868.
Teign R. §§ 779, 781, 782, 792, 793, 882.
Teignmouth, §§ 778—781, 792.
Thurlestone rocks, § 837.
Topsham, §§ 756, 757.
Torbay, §§ 799—805, 814.
Torquay, §§ 800—802.
Totness, §§ 818—821, 823, 824.

U.

Ugbrook, § 791.
Uphill, § 898.
Upway, § 559.

V.

St. Vincent's rock, §§ 707—712, 716.

W.

Wareham, §§ 593, 674—676, 683.
Warley, §§ 731, 732, 735.

Watcomb cove, § 794.
Week, §§ 700, 701.
Wells, § 933.
Westbury, § 725.
Weston super mare, § 901.
Wey R. §§ 476, 560, 565, 569, 571—575.
Weymouth, §§ 476—492, 559, 560, 562—575, 588.
Wight I. §§ 599—601, 605, 610—640.
Witcombe, § 733.
Witsand bay, §§ 873 *a*, 878.
Woodbury, § 761.
Wookey hole, §§ 910, 925, 926.
Wyke Regis, §§ 480, 483, 484, 513.

Y.

Yarmouth, §§ 605, 610, 611.
Yealm R. §§ 851, 882.
Yealmouth, § 850.
Yealmpton, §§ 850, 851.

END OF THE SECOND VOLUME.

PRINTED BY LAW AND GILBERT, ST. JOHN'S SQUARE, LONDON.